Vol. 16, No. 1 January, 1960

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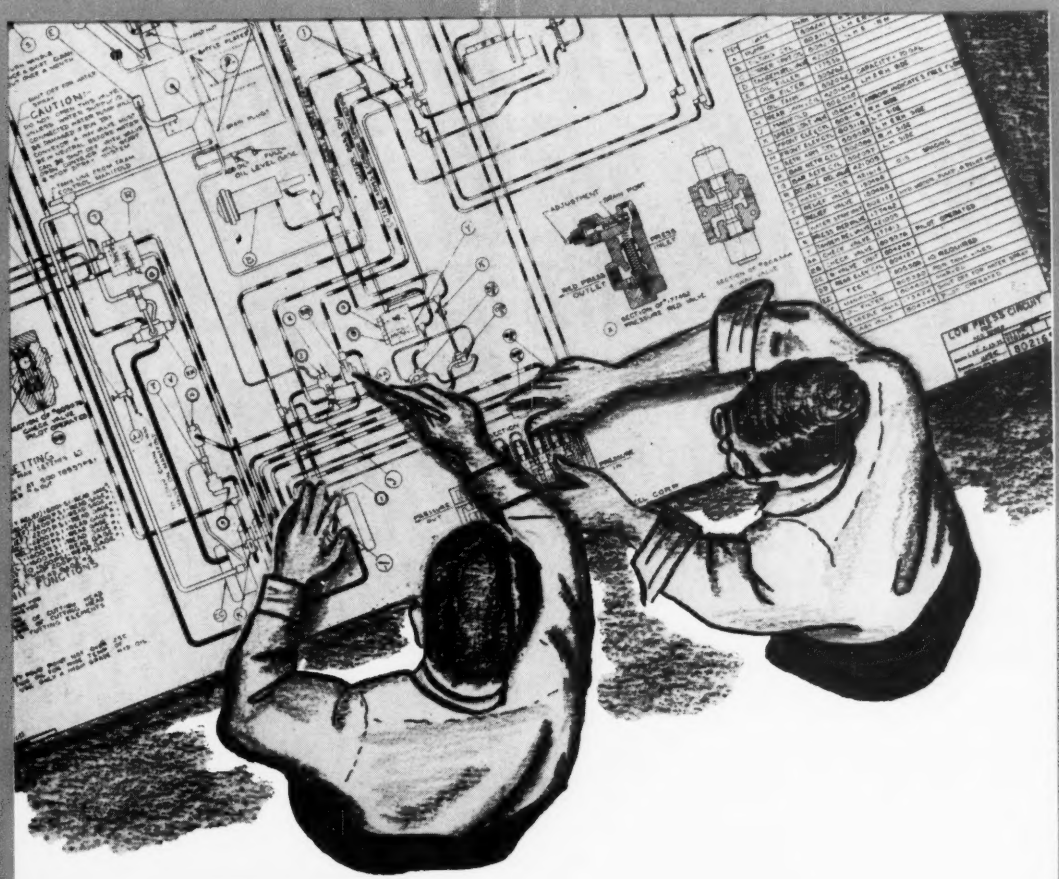
HODSON
CORP

LUBRICATION ENGINEERING

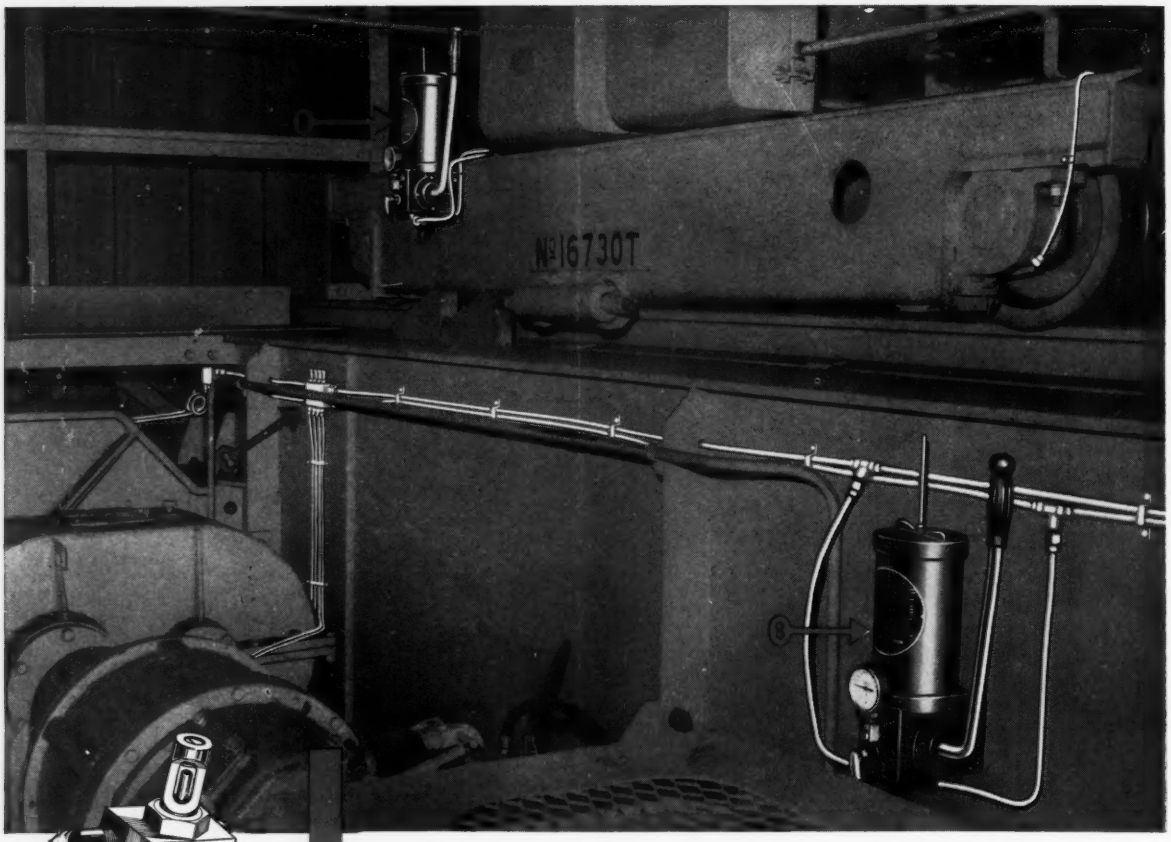
DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

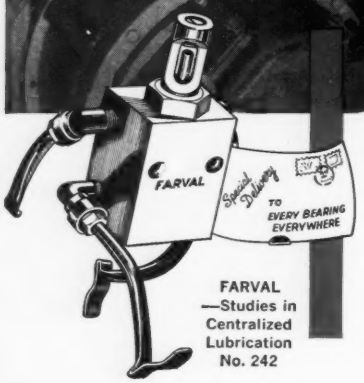


this month.....

REDUCING LEAKAGE FROM HYDRAULIC SYSTEMS

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS





FARVAL
—Studies in
Centralized
Lubrication
No. 242

Farval lubrication installed on new Harnischfeger electronically controlled overhead crane

When Harnischfeger Corporation, Milwaukee recently demonstrated its new electronically controlled, heavy-duty overhead crane, it was equipped with a Farval centralized, full-protection lubrication system.

Why?

Because Harnischfeger engineers knew from past experience that a Farval centralized lubrication system can always be depended upon to provide the right amount of lubrication — when it's needed, where it's needed — for the rugged-going that giant overhead traveling cranes meet in their daily shop service.

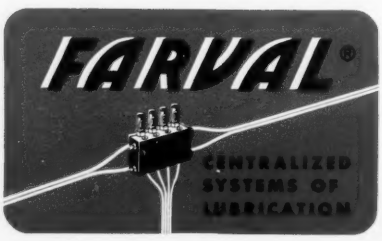
Remember, for the ultimate in bearing protection on all types of industrial production machines and equipment — Farval is the cost-cutting answer. Get the latest information on how Farval can fit into your production picture — it's in free Bulletin 26-S. Write us for your personal copy, today.

The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company
A subsidiary of Eaton Manufacturing Company

KEYS TO ADEQUATE LUBRICATION

Wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and pump stations —you know industrial equipment is being properly lubricated.



Volume 16, No. 1
January, 1960

Lubrication Engineering

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

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LUBRICATION IN THE NEWS

The Society will not be responsible for the accuracy of statements made in this column. Any reference to proprietary products does not imply an endorsement of such products by the Society.

Savings with Microfilm Catalogs

By breaking a communications log jam in the missiles and aircraft industry, a microfilm catalog service will save engineering and procurement time estimated to be in excess of $60 million every year. This development in industrial communications is called the VSMF (Vendor-Specs-Microfilm-File) Microfilm Catalog Service. It contains engineering specifications on all types of components and materials used in the construction of missiles and aircraft.

The system makes use of microfilm and a film projection device developed by the Recordak Corp., subsidiary of Eastman Kodak Co. The reading device "blows up" the miniature picture from the film into a full-size image in front of the operator, where it may be easily studied or where a direct copy of the displayed information may be made.

To use the device, the separately-printed product index is consulted to find which film reel contains the information he needs. Selected from a rack on the machine, the reel is quickly slipped into the reader. Two switches control the movement of the film through the reader. Average "finding time" is less than 15 seconds. The VSMF file capitalizes on microfilm's ability to condense volumes of information into an incredibly small space. For instance, the VSMF system converts the contents of a three-cubic-foot file drawer into a film cartridge measuring one three-hundredth of the drawer's size. The saving to many missiles manufacturers using VSMF amounts to acres of filing space and permits the application of filing clerks and librarians to other activities where their special skills are more productive.

Studies within the industry indicate that engineering personnel spend 7.3 hours per week in search of product information. The VSMF microfilm file allows the engineer to quickly find information which he knows is complete and up-to-date.

In addition to the Department of Defense, VSMF installations will be in use early in 1960 at a number of plants.

Introduction of the Missiles/Aircraft Microfilm Catalog Service has precipitated demand for similar files serving other industries; Technical Services Division plans to have four other such files ready during 1960.
(Source Rogers Pub. Co.)

New Metalworking Directory Compiled

There are 31,084 metalworking and metal producing plants in the United States employing 20 or more persons. Of these 31,084 plants, 11,141 employ 100 or more persons, 7,111 employ 50 to 99 persons and 12,832 employ 20 to 49 persons.

A geographic analysis of these statistics reveals 3,502 of the total 31,084 metalworking plants are located in New York State. The next five top ranking states were: California with 3,294 plants; Illinois, 3,191; Ohio, 2,852; Michigan, 2,522; and Pennsylvania, 2,397.

This information was gathered by Dun & Bradstreet Inc. and is published in a Metalworking Directory that will be issued as a national edition, and also in five regional editions. The Directory is indexed under three principal headings: geographically by states and cities; alphabetically by name of business; and functionally by product classification. In addition, the Directory contains a statistical summary showing the number of plants by line of business and by number of employees in each county in the United States.
(Source, Dun & Bradstreet, Inc.)

Atomic Ship to Use Special Bearings

Huge special ball thrust bearings will be used to install the fuel elements in the nuclear reactors of the N. S. Savannah, the world's first atomic cargo-passenger ship.

Two bearings of 106 inches and 64 inches diameter will be installed in the mechanism called the charging plug, which rotates in order to locate the refueling cask in the various positions necessary to load the fuel core.

Close tolerances are held to obtain parallel surfaces and accurate concentricity of these bearings. To meet these critical tolerances, special two-head precision grinders are used in the manufacture. Special methods are also used in the deep flame-hardening of the bearing raceway surfaces, which permits proper hardening without the usual distortion of such large rings.

The N. S. Savannah is being built under President Dwight D. Eisenhower's Atoms-For-Peace program. It will serve as a working example of the peaceful use of the atom. The ship is a joint venture of the Atomic Energy Commission and the U.S. Maritime Administration.
(Kaydon Engineering Corp., Muskegon, Mich.)

(*Con't. on p. 7*)

SECTION NEWS

CHICAGO—John W. Waite, Inland Steel Company, discussed "Unique Problems in Steel Mill Lubrication and the Lubrication Engineer" at the November 19 meeting ..... BALTIMORE—November meeting had Mr. Shortly of Western Electric as guest speaker. His subject was "A Ten Point Lubrication Standardization Program." ..... HUDSON-MOHAWK—"Elastic Losses in Rolling Friction" was discussed by Dr. D. G. Flom, Research Labs of General Electric Co. at November 18 meeting ..... HUNTINGTON-CHARLESTON—ASLE Eastern Regional Vice President, D. F. Wilcock, General Electric Company, spoke on the subject "Lubrication of Ball Bearings" at the regular November meeting.....PITTSBURGH—November meeting features a panel discussion on "Grease Lubrication." J. S. Aarons acted as moderator for the panel comprised of J. T. Bunting, ALCOA; E. C. Gauron, Fafnir Bearings; W. G. Ritter, Ritter Engineering Company, and B. W. VanOrmer, Sun Oil Company. ..... TORONTO—Dr. Charles L. Pope, Chief Lubrication Engineer, Eastman Kodak Company, was guest speaker at the November 10 meeting. "Theory and Practice of Bearing Lubrication" was the subject of his talk which was followed by a lively discussion.

Photo above was taken at the October joint meeting of the Rochester and Buffalo sections. Left to right are R. H. Knowe, Chairman Rochester; C. L. Miller, Eastman Kodak Company, guest speaker; T. W. Langer, Chairman Buffalo. Mr. Langer died on November first.

Lube Conference Highlights

A. C. West, Lubrication Conference Chairman, extends welcome to Conference attendees.

(left to right) L. E. Hoyer; E. Landau; A. C. West, Conference Chairman; S. Manilych; H. D. Lewis.

A. A. Raimondi, chairing the session on Hydrodynamic Bearings.

R. L. Johnson, Vice Chairman, presides over session on Lubrication for Advanced Flight Vehicles, while Douglas Godfrey, Chairman, and C. Goodzeit, Vice Chairman of session on Basic Friction and Wear, look on.

ASME Ladies Auxiliary provide refreshments.

ASLE Joint Lubrication Conference Papers

☐ **"An Analytical Investigation of Visco-Elastic Effects in the Lubrication of Rolling Contact,"** by R. A. BURTON, Southwest Research Institute, San Antonio, Texas.
No. 59LC-1

☐ **"Meta-Linked Polyphenyl Ethers as High Temperature Radiation Resistant Lubricants,"** by C. L. MAHONEY, E. R. BARNUM, W. W. KERLIN and K. J. SAX, Shell Development Co., Emeryville, Calif.
No. 59LC-2

☐ **"The Calculated Journal Bearing Performance of Polymer Thickened Lubricants,"** by H. H. HOROWITZ and F. E. STEIDLER, Esso Research and Engineering Co., Linden, N. J.
No. 59LC-3

☐ **"A Comparison of Lubricants and Coating for Cold Extruding Titanium,"** by A. M. SABROFF and P. D. FROST, Battelle Memorial Institute, Columbus, Ohio.
No. 59LC-4

☐ **"Sliding Characteristics of Metals at High Temperatures,"** by M. B. PETERSON, J. J. FLOREK, and R. E. LEE, General Electric Co., Schenectady, N. Y.
No. 59LC-5

☐ **"Evaluation of Gear Materials Scoring at 700°F,"** by E. G. JACKSON, C. F. MUENCH, and E. H. SCOTT, General Electric Company, West Lynn, Mass.
No. 59LC-6

☐ **"Gear Lubrication in Inert Gas Atmospheres,"** by B. B. BABER,* C. W. LAWLER,* H. R. SMITH,** G. A. BEANE,** and P. M. KU,* *Southwest Research Institute, San Antonio, Texas, and **Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.
No. 59LC-7

☐ **"A Research Program on the Investigation of Seal Materials for High Temperature Application,"** by R. H. BASKEY, Horizons, Inc., Cleveland, Ohio.
No. 59LC-8

☐ **"The Effect of Root Lubrication on the Damping of Cantilever Beams,"** by R. V. KLINT and R. S. OWENS, General Electric Company, Schenectady, N. Y.
No. 59LC-9

☐ **"Transition Temperatures with Four-Ball Machine,"** by R. S. FEIN, Texaco Research Center, Beacon, N. Y.
No. 59LC-10

☐ **"The Influence of Silicon Additions on Friction and Wear of Nickel Alloys at Temperatures to 1000°F,"** by D. H. BUCKLEY and R. L. JOHNSON, National Aeronautics and Space Agency, Cleveland, Ohio.
No. 59LC-11

☐ **"Distribution of an EP Film on Wear Surfaces,"** by R. C. WIQUIST, S. B. TWISS, and E. H. LOESER, Chrysler Corp., Detroit, Michigan.
No. 59LC-12

Please send me the preprints as checked from the Joint Lubrication Conference. Enclosed please find_____(each preprint $.50 for members, $.75 for nonmembers).

My name _____

Address _____

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State _____

NEW PRODUCTS

The Society will not be responsible for the accuracy of statements made in this column. Any reference to proprietary products does not imply an endorsement of such products by the Society.

JOINT SEALING TAPE ELIMINATES DOPE

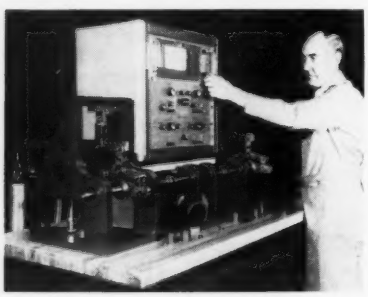
A chemically-inert plastic tape designed to seal and permanently lubricate threaded and coupled pipe joints, has been announced by the Minnesota Mining and Manufacturing Co.

Called "Scotchrap" Dry Thread Sealer No. 4212, this unfused film can be applied in seconds and conforms to all types of pipe threads and fittings in any pipe system, low pressure or high, according to the company.

Made with a TFE-fluorocarbon resin, the tape can withstand temperatures from that of liquid-oxygen through that of super-heated steam. It is reported to be unaffected by oil traces or other lubricants in the steam line. Although non-adhesive, the tape is sufficiently cohesive to stick to its own glossy surface as well as any pipe thread.

It is said to eliminate the need for brushing dope solutions on fittings, while due to its anti-sticking characteristics, joints can be loosened and detached years after the threads are taped. It is available in ½-inch widths, in rolls 260-inches or 520-inches long.

Further information may be obtained from the Minnesota Mining and Manufacturing Co., Irvington Division, 900 Bush Avenue, St. Paul 6, Minnesota.



TWO-IN-ONE BEARING TESTER AVAILABLE

The Arguto "Simulife" Bearing Tester is reported by the manufacturer to fill the need for a means of testing and comparing bearings under conditions which simulate those of actual in the field operation.

Speed, load, ambient temperature and lubrication can be varied and controlled while the machine makes a permanent record of friction force, bearing temperature and time. Coefficientof friction, temperature rise, bearing clearance, wear, PV values and bearing life can be measured or determined while the machine is in operation.

To further increase its usefulness, the machine is designed so that two bearings of the same or different materials can be tested simultaneously, while both frictional force and bearing temperature are continuously recorded for each of the bearings as the test progresses. Although developed primarily for testing boundary lubricated, oilless, and dry lubrication bearings, it can be used equally well for testing rolling element bearings.

Basically the "Simulife" Bearing Test Machine consists of two shafts which are driven thru a variable speed drive to give shaft speeds of from 50 fpm to 1000 fpm. The bearings to be tested are pressed into retaining rings which are inserted in the bearing support arms. Each bearing support arm is part of a parellelogram mounted on hardened knife edges. The bearing is loaded by means of a levered weight arm so that loads may be varied from zero to 1000 lbs..

Friction force is measured by strain gages mounted on a torque arm and is recorded directly on one channel of a dual channel oscillograph. Bearing temperature is measured by means of a thermocouple buried in the loaded side of the bearing wall and recorded on the second channel of the oscillograph. Shaft speed is indicated directly on a tachometer.

The "Simulife" Bearing Test Machine is available in both single and dual models. The instrumentation used on these recording models, consists of a universal amplifier, a high gain D.C. amplifier and a dual channel combination oscillograph. For further information write Arguto Oilless Bearing Company, 149 Berkley Street, Philadelphia 44, Pa.

ASHLESS ANTIOXIDANT

A new general purpose, ashless antioxidant based on a mixture of aryl amines now is available from the Du Pont Company for use in greases, turbine and crankcase oils, and ester lubricants.

To be marketed as "Ortholeum" 302 antioxidant, the compound, when used as a stabilizer in synthetic lubricants is said to effectively inhibit viscosity change, copper corrosion, and acid number increase in high temperature oxidadation tests. In automobile engine and laboratory bench tests, the new product is said to reduce bearing corrosion, oxidation, and acid formation in mineral and synthetic oils as well as greases.

The antioxidant, according to the manufacturer, generally is effective at low concentrations.

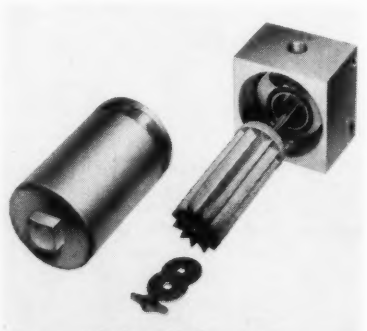
Further information may be obtained from the Du Pont Company's Petroleum Chemicals Division, Wilmington, Delaware.

HYDRAULIC FLUID FILTER

A new type of hydraulic fluid filter, featuring a reinforced sintered bronze 40-micron filter element, is announced.

In the ⅜ inch size, the filter area is 35 sq. inches. Its design is said to assure that an accumulation of foreign matter causing a pressure drop of a much as 400 psi across the element will not cause the element to distintegrate. At pressure drops higher than 400 psi, the element may merely crack, but downstream components are protected from particles and small pieces of the element.

The filter element is reuseable; it may be cleaned by washing in a solvent and reverse blowing with air. It is contained in a forged aluminum bowl threaded to an extruded aluminum head. O-ring seals are used. The unit is rated at 100 psi operating pressure.



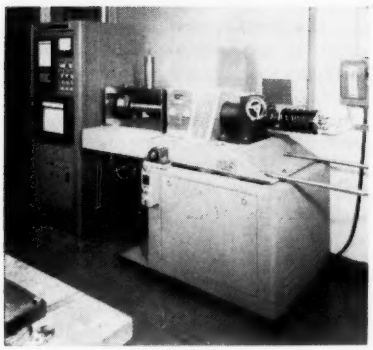
Also available is a similar assembly for ¾ inch pipe connections, utilizing two filter elements in parallel.

The filters are for use with petroleum, ester, or glycol based hydraulic fluids, silicones, water, and air.

Request Bulletin M1 from GPE Controls, Inc., 240 E. Ontario St., Chicago 11, Ill.

NEW PRODUCTS
(Continued)

LUBRICANT TESTING MACHINE ANNOUNCED



A new lubricant testing machine designed for environmental research has been announced by the Alpha-Molykote Corporation.

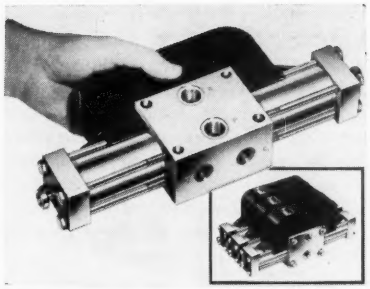
The machine, known as the Model LFW-3, reportedly can be adapted to testing either dry or liquid lubricants, at ambient to high temperatures, with oscillatory or rotational motion, over a wide range of velocities and loads. A high temperature furnace is supplied as standard equipment. A 5 H.P. motor allows the machine to operate at friction coefficients of .5 at full load.

The Model LFW-3 is furnished complete and ready to operate with all electrical equipment necessary to give full protection against overload and low voltage. Instrumentation is mounted in a separate cabinet wired for easy connection to or disconnection from the testing machine.

For detailed specifications of the Alpha Model LFW-3 Lubricant Testing Machine, write the Alpha-Molykote Corporation, 65 Harvard Avenue, Stamford, Conn.

NEW SOLENOID VALVES PROVIDE EXTRA FEATURES

A new line of four-way A.C. solenoid valves is reported by the manufacturer to provide a combination of high fluid capacity, high pressure ratings, light weight, and low current consumption. The valves are rated at 3000 psi. Rated pressure may be applied to all ports. The direct-actuated spool requires no back pressure or minimum flow for proper operation. Full-size porting and simplified inner design provides a pressure drop of about 60 psi at five gpm. Valve body material is high-strength aluminum alloy, with heat-treated steel spools and sleeves. All working parts are enclosed and immersed in the hydraulic fluid. Standard construction includes



static seals that are compatible with all petroleum-base fluids. Valves for other types of hydraulic fluids are also available. As shown in the photo, the valves are designed for easy stacking or banking.

Solenoids designed to reduce inrush current allow fast cycling without excessive heating. Cycling rates greater than 60 cpm are reported to be practical. Valves are available for 110 or 220 volt operation. For electrical connections, a terminal strip is provided and is protected by a steel housing with a standard conduit connection. Manual operation is possible for emergency operation, or to permit system checking without electrical power.

For detailed information, dimensions, pressure drop curves, etc., write to Waterman Hydraulics Corp., 725 Custer Ave., Evanston, Ill.

NEW CENTRIFUGES MADE IN FOUR SIZES

Continuous high capacity solids dehydration (up to 70 tons per hour) is said to be provided in the new line of conical screen centrifuges announced by Sharples Corp. Available in four sizes, this centrifuge permits handling of a wide variety of slurries containing relatively large sized crystalline solids, as well as fibrous pulps, with residual moisture as low as 1 per cent.

The new line is designed for in-use flexibility that provides low-cost, high-efficiency operation. A wide range of degrees of liquid clarity and/or solids dryness can be achieved because the perforate screen through which the mother liquid passes can be changed, and the rotational speed varied. Greater solids dryness is said to be possible than with centrifuges of conventional design, due to the unique conical construction of the bowl assembly and the application of high centrifugal force.

Additional information on the new Sharples line is available on request to The Sharples Corporation, 2300 Westmoreland Street, Philadelphia 40, Pa.

Just Published!

A great new technical reference work

MARINE LUBRICATION

by G. H. Clark
Esso Petroleum Company

This comprehensive, authoritative handbook contains over 600 pages of practical, technical information on every aspect of lubrication from fundamentals to advanced applications in atomic plants, atomic reactors and operating circuits. Virtually a one-volume encyclopedia, it offers a wealth of up-to-date material for industrial as well as marine engineers. More than 250 illustrations, dozens of charts and tables. $16.00

TYPICAL CHAPTERS

Refining of Lubricating Oils. Lubrication-Fundamental Principles. Journal Bearings. Lubricating Oil and Fuel Oil Filtration. The Lubrication of Marine Prime Movers. Reciprocating Steam Engines. Exhaust Steam Turbines. Corrosion of Steam Turbine Oil Systems. Steam Turbine Lubricating Oil Systems. The Lubricating of Turbine Gearing. Modern Gear Designs. Flexible Couplings—Gear Sprayers—Oil Coolers. Cleaning of Turbine Oil Systems. Turbine Oil Maintenance. Scavenging and Pressure Charging of Diesel Engines. Piston and Piston Ring Design. Marine Diesel Engine Lubrication. Improved Diesel Engine Cylinder Lubricants. Mechanical Lubrication of Diesel Engine Cylinders. Diesel Engine Crankcase Oil Systems. Corrosion of Working Parts in Crankcases of Marine Diesel Engines. Minimizing Crankcase Corrosion. Crankcase Oil Maintenance. Free-piston Gas-generator Turbine. Marine Gas Turbines. The Elements of Nuclear Technology. Nuclear Propulsion of Ships. Indirect Diesel Propulsion. Index.

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Enclosed is $16. ☐ check ☐ money order

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Next Month ! !

–BEARINGS–

An issue devoted to this subject

Behavior of Lubricated Ball Bearings in Controlled Atmospheres

The peaceful use of nuclear power and the proposed journey of man into space are two areas where operation of bearings in gaseous environments free of oxygen and water vapor or vacuum appear to be inevitable. This article reports on the bearing performance.

Determination and Correlation of Fundamental Instrument Bearing Parameters

Unique ultra-precise instruments are required to measure and evaluate dimensional, geometrical and performance qualities of miniature instrument ball bearings. The instrumentation used—particularly the development of a bearing quality analyzer will be described. Also actual tests on use, correlation, and interpretation of these instruments and test data will be reported.

Progress in Roller Bearing Lubrication

Results of laboratory and field services tests will be presented to show the progress being made toward operation of freight car journal bearings over a four-year period without adding grease. A discussion of the bearing corrosion problem on inactive freight cars will be presented. Also —advantages of phosphate coating the roller bearing for corrosion protection; features of an adequate seal design; electron optical studies for qualifying grease.

PRODUCT LITERATURE

NEW DATA AVAILABLE ON LIGNUM-VITAE

A series of informative Bulletins, Test Reports and Technical Brochures is now available from the Lignum-Vitae Products Corp. This literature covers engineering and design information on Lignum-Vitae as a friction reducing material.

This material is available from Lignum-Vitae Products Corp., 97P Boyd Avenue, Jersey City 4, New Jersey.

PAPER ON PETROLATUM IN PRINTING INK

A technical paper on petrolatum in printing ink is available from L. Sonneborn Sons, Inc., New York, petroleum refiner and manufacturing chemist.

The paper describes the major properties of petrolatum essential in the formulation of printing inks. Such as softening, retarding drying, reducing tackiness and extending.

In addition, information on the proper types and grades of petrolatum to be used is given. Complete application and test data is included. Copies may be obtained by writing L. Sonneborn Sons, Inc. 300 Park Avenue South, New York 10, New York.

TUBE FITTINGS SELECTOR

Four page folder offers condensed information to help select proper fittings for various service and installation requirements. Include shape charts for six types of industrial tube fittings and illustrations of tube-working tools. Ask for Bulletin 4306B1 from W. D. Wynant, Parker Fittings & Hose Division, Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.

BULLETIN DESCRIBES ROTARY GEAR PUMPS

A new bulletin describing Northern Nitralloy Rotary Gear Pumps, manufactured by Northern Ordnance Incorporated, is now available.

This illustrated bulletin explains design features and presents detailed tables giving dimensions, capacities in gallons per minute from ¼ to 146 GPM, horsepower ratings, pressures (up to 2000 psi) and revolutions per minute.

It tells how Northern Nitralloy Pumps are semi-custom designed through the use of interchangeable pumps sections and materials to meet the needs of intended use. It also points out many of the hundreds of applications where these pumps are used.

For your free copy of Bulletin 42, write to Northern Ordnance Incorporated, Minneapolis 21, Minn.

REPORT ON MOLY BONDED FILMS AVAILABLE

A new 8-page report, complete with 16 comprehensive charts, covering moly bonded films has just been released by Bemol, Inc. This technical report presents design information affecting the wear life and frictional properties of moly bonded films. Subjects covered in this report are speed, load, time, temperature, film thickness, surface finish, surface pretreatment, solid lube type, and bearing hardness. Typical uses, technical data, design tips, and recommendations are included. The brochure is designed to be used as a working guide for lubrication and design engineers. Copies of the report, entitled "Design Information on Moly Bonded Films," are available from Bemol, Inc., 131 State Street, Boston 9, Mass.

PERSONALS

Magnus Chemical Company, Inc., recently announced the election of three new directors. They are **Leon Salz,** Richard P. Edmonds, and P. Edward Gabelmann.

Lawrence C. Brunstrum, section leader in lubricants research at the Whiting research laboratories of Standard Oil Company (Indiana), has been selected chairman of the General Technical Committee of the National Lubricating Grease Institute. As chairman, Mr. Brunstrum will direct activities of several sub committees in such fields as basic research, testing, and manufacturing.

Frederick C. Westphal, Jr., has become manager of Esso Standard Oil Company's Bayonne (N. J.) refinery, effective December 1, the company recently announced. He has been administrative superintendent of Esso's Bayway refinery, Linden, N. J., for the last year.

L. R. Kerns Company, Chicago, has announced the appointment of Thomas E. Thorpe as Manager of technical sales —rolling oils division.

Victor F. De Vinny has been appointed Sales Manager of the Whistlelean Corporation, a subsidiary of L. Sonneborn Sons, Inc., New York, petroleum refiners and manufacturers of chemicals and building products.

O. V. Tracy was elected today to succeed William Naden as president of Esso Standard Oil Company. Robert H. Scholl succeeds E. Duer Reeves as executive vice president.

LETTERS TO THE EDITOR

Lubrication Engineering welcomes the comments and suggestions of readers with regard to articles published in its pages or concerning topics of interest to those engaged in any phase of lubrication engineering. Letters received cannot be acknowledged, but those felt to be of interest to other readers will be published. The Society will not be responsible for the statements or opinions expressed.

Sir:

In the November, 1959 issue of LUBRICATION ENGINEERING, I ran onto an article by M. A. Hanson entitled "Developments in Railroad Journal Bearings."

I was amazed at the lack of attention to details of oil entry to both the load supporting and thrust surfaces of the bearings illustrated in Figures 4, 8, 9 and 10. Although the load supporting surface is lightly loaded according to large internal combustion engine practice, I cannot see where any effort has been made to insure entry, particularly with a bearing which has worn to any extent. A possible exception is in Figure 10 where, in the upper right hand view, chamfers are indicated. In my opinion, these should be radii tangent to the bore along both edges.

I believe a similar thing is true of the thrust faces for in the upper left hand view of Figure 10, I see sharp scraping edges.

I am further surprised at the use of ¼ inch thick babbitt in this day and age when it has so thoroughly proven, and my own experience confirms this, that so-called "Micro-Babbitt" bearings have a much greater fatigue life. Six per cent failures due to loose and broken linings are an appreciable goal to go after and I wonder if the bronze back bearing with a plated lead base babbitt lining from .002 to .004 inches thick has been investigated. Oil entry radii and even some grooves on the thrust faces might make considerable improvement.

I realize that a great deal of thought has been put into this problem for many years but often a different viewpoint helps.

Basically, every journal size shown would be a better bearing if its dimensions were reversed. A nine inch diameter bearing five inches wide will give better load distribution and will be better lubricated than the present five by nine. I realize the impossibility of such a change at this time. The railroads have other more serious problems.

M. S. Parkhill
Ingersoll-Rand Co.
Painted Post, New York

Sir:

I would like to point out that in my discussion of a paper by A. C. Borg and R. H. Leet, published in the November issue of LUBRICATION ENGINEERING, (Effect of Thickener-Particle Dimensions on Lubricating Grease Properties) there was one error in Table 4 which may be misleading to readers. If it is possible, I would appreciate your publishing a corrected table.

Very truly yours,
J. Panzer
Esso Research & Engineering Co.
Linden, N. J.

Editors note: corrected table appears below.

CORRECTED TABLE 4

CALCIUM COMPLEX GREASES

PARTICLE SIZE VS. PROPERTIES

PARTICLE SIZE DISTRIBUTION, % L/W 2-8 LENGTH 0.1-0.2μ	L/W 10-100 LENGTH 1-3μ	VISCOSITY, POISES	SHEAR BREAKDOWN	OIL BLEEDING, %
28	72	140	Little	6.2
42	58	153	Moderate	3.2
50	50	200	Great	3.1

LUBE IN THE NEWS

(Con't. from p. 2)

Lubrication Seminar Success in Switzerland

A two day Seminar on Friction, Lubrication and Wear was held in Lucerne, Switzerland in September, 1959. The Seminar was organized by the Alpha-Molykote Corporation and it brought together a group of about seventy-five engineers and outstanding European scientists who are professionally concerned with the practice and theory of lubrication, friction and wear phenomena.

Dr. G. Salomon, editor of the international magazine Wear, Delft, Holland was chairman and discussion moderator for the first day's session and Dr. G. H. Gottner, Institute for Petroleum Research and Publisher of the German magazine on friction and wear *Schmiertechnik,* Hanover, Germany was chairman and discussion moderator for the second day's session.

Copies of two of the technical papers will be available from the Alpha-Molykote Corporation, 65 Harvard Ave., Stamford, Connecticut as soon as the translations are completed.

Plant Finds Need to Expand

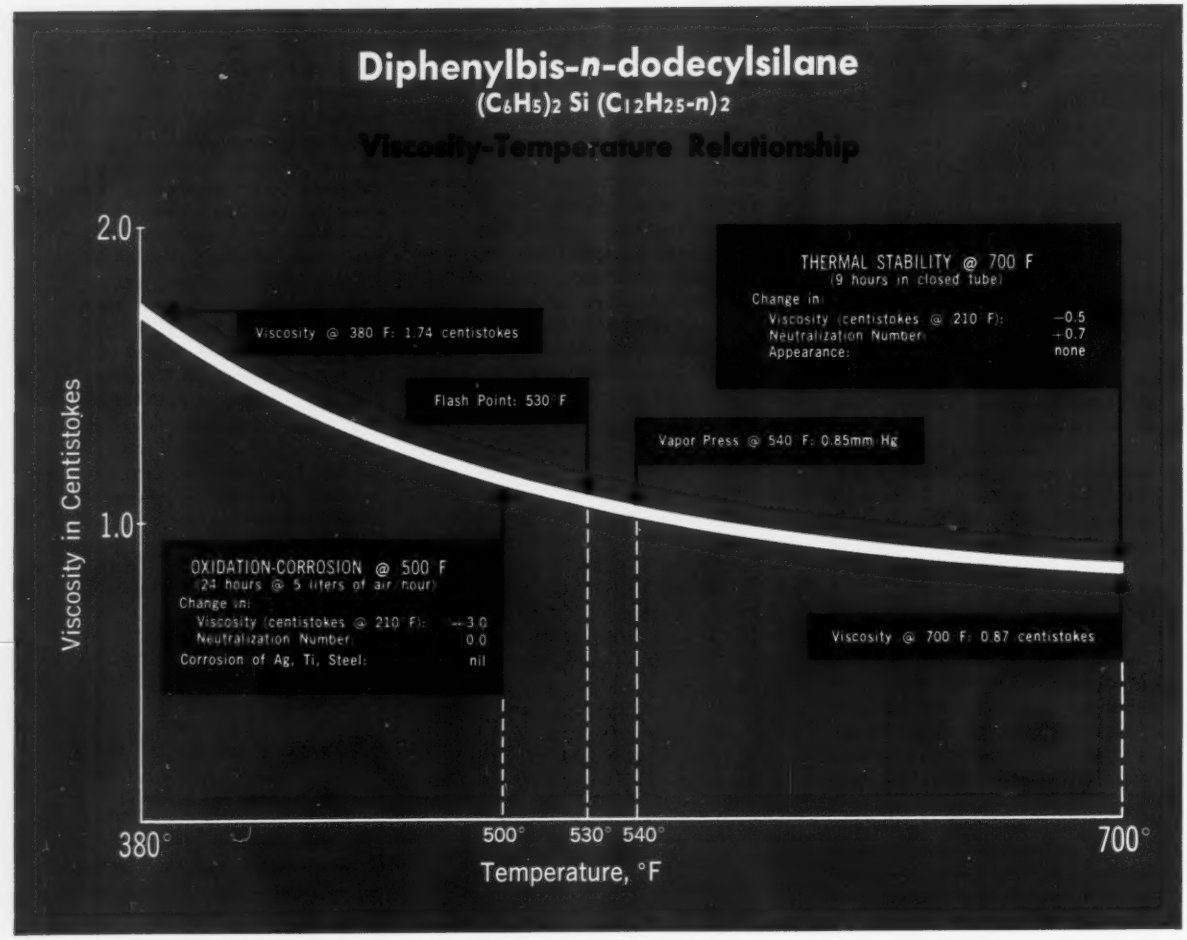
American Potash & Chemical Corporation announced today that work has begun to enlarge the company's $4,400,000 sodium chlorate plant at Aberdeen, Miss. by 50 per cent to satisfy increased consumption by the pulp and paper industry.

The expansion project, which will represent an investment of approximately $1,250,000, will raise production capacity at Aberdeen from 15,000 tons per year to 22,500 tons. Completion is scheduled for October, 1960.

Capacity of the Aberdeen plant combined with that of American Potash & Chemical Corporation's Henderson, Nev., facility will exceed 50,000 tons of sodium chlorate per year to make the company the world's largest producer.

Cost of the current expansion is relatively low because part of the original $4,400,000 plant investment included provisions for increasing production 100 per cent if market conditions warranted such a move. In addition to the present expansion, another 50 per cent increase can be made at correspondingly low cost.

A New, Extremely Stable High-Temperature Lubricant



The temperature-viscosity curve above highlights the prime qualifications of M&T's DIPHENYL bis-*n*-DODECYLSILANE as a stable, high-temperature fluid.

Negligible change in viscosity plus excellent thermal and oxidation-corrosion stability make DIPHENYL bis-*n*-DODECYLSILANE an excellent choice for evaluation in lubrication or hydraulic systems involving high-temperature conditions.

Send for Technical Data Sheet DS-100 containing complete physical information on this new M&T organometallic.

M&T Chemicals

COMMERCIAL DEVELOPMENT DIVISION
Metal & Thermit Corporation
100 Park Avenue, New York 17, N. Y.

Sn Sb P | organometallics
Si Ti Zr | and inorganics

Lube Lines

by A. F. Brewer*

MAINTENANCE

Modern maintenance is a form of preventive medicine. The "remedy" idea is outdated. Trouble must be anticipated before it occurs. When production or power plant machinery was going through the development stage a pinch of sulfur might have been alright to temporarily solve the problem of a hot running bearing, or a portable electric fan might have sufficed. Today the lubrication procedure and the type of lubricant constitute the best "medicine."

Maintenance of course can be a varied responsibility because it usually must cover the entire assembly of machinery in the plant. For this reason the maintenance personnel should be trained artisans, machinists or millwrights who can take over when the operators report trouble. The relation of these latter to the maintenance people is most important because the machine operators are the front line force charged with the actual productive ability of their machinery, whether it involves power, heavy machinery components, durable goods or any of the variety of modern living conveniences. Since the operators are most closely associated with the production line they normally will be the first to sense impending trouble. Variation from the normal pulsing sound of the unit may develop, or possibly an unusual odor will be detected, or excessive heat indicated by touch. The sense of touch can be the first indication of abnormal temperature conditions which could lead to costly gear or bearing maintenance if the probable accompanying increase in wear rate is not corrected. So often a slight adjustment by a trained machinist, with possibly a change in the rate or type of lubrication (after consultation with the lubrication engineer) will bring the machine back to normal with no disruption of the production schedules.

The Responsibility

In scheduling a table of responsibility for the various departments in the modern plant the maintenance department can be regarded as responsible for

(a) Supervising the condition of lubrication piping and fittings.
(b) Correction of leaks.
(c) Removal, cleaning and reinstalling of bearings and couplings.
(d) Check-up on the mechanical condition of gears and chains, as to tooth or link wear.
(e) Check-up on gear and chain drive housings as to tightness, gasket seal, etc. to prevent lubricant leakage or entry of non-lubricating foreign matter.
(f) Replacement of worn bearings, damaged gears, couplings or chains.
(g) Cooperating with the lubrication department in correcting operating deficiencies in oil-circulating or pressure greasing systems.
(h) Checking effectiveness of cooling (or heating) systems when installed as component parts of lubricating systems.

Lubricating Equipment

The actual work in connection with the maintenance of lubricating equipment may be the responsibility of the maintenance or the lubrication department according to the layout and expanse of the plant. Any extensive application of automatic lubrication will involve some piping or projecting parts which could be crushed, broken or otherwise damaged by contact with swinging crane parts when moving materials, or by careless handling of tools. If damage of this nature is not corrected promptly, serious harm could result to the machine itself from inadequate lubrication. Unscheduled shutdown for repair would very likely involve production loss and unwarranted maintenance costs. Obviously all plant personnel should be instructed as to this possibility, and schooled in materials handling and respect for the lubricating systems. To make sure of this the maintenance and lubrication departments would do well to organize a preventive inspection and training program which would include

(a) Frequent inspection to make sure that lubricating equipment is in proper operating condition.
(b) Training of their personnel in repair procedures, both for correction of minor difficulties on the job, and complete overhaul of such equipment in the shop or repair station. Here dismantling for replacement of worn parts preparatory to reinstallation can be done.

As considerable knowledge of mechanics is required in order to work on the mechanisms of modern lubricating systems, the personnel must be carefully selected and properly instructed as to the working ability of the various types of feeder valves, pumps, metering devices and switches.

Maintenance and major repair work can be expedited when the machine shop or repair station is located strategically with respect to main plant machinery, in order to reduce time loss in handling the

(*Con't. on p. 40*)

* Consultant and author "Basic Lubrication Practice."

250,000 Power Tools per year with Cities Service Pacemaker T

Porter-Cable, one of the world's largest manufacturers of portable wood-working tools, has long known the value of quality in a lubricant as well as in a power tool. Each piece of equipment made by Porter-Cable is carefully pretested before manufacture and then continually tested for years after its original appearance on the market. It is this kind of thoroughness that led to Porter-Cable's choice of Cities Service Pacemaker 300 T as the hydraulic oil to power their Fostermatic Screw Machines and Landis Grinders.

But Cities Service Pacemaker T is more than a hydraulic oil . . . it is a multi-purpose line of lubricants suited for many applications. Porter-Cable also uses Pacemaker 300 T for lubricating valves in the plant's compressors. Pacemaker T can be used to lubricate bearings, diesel engines, electric motors, generators, reduction gear drives, turbines and in circulating systems.

Pacemaker T is available in various viscosities to give you one line of quality lubricants that can save costly warehouse space by simplifying your inventory . . . cut maintenance costs and extend equipment life. These oils have high viscosity index, excellent heat resistant properties and are chemically fortified against oxidation, corrosion, rust formation and foaming.

Contact your nearest Cities Service office and an experienced Lubrication Engineer will call to make specific recommendations for your plant on the use of Pacemaker T. Or for further information, write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE
QUALITY PETROLEUM PRODUCTS

Porter-Cable Machine Company
Syracuse, New York

Porter-Cable Research Engineer testing engine for new lawnmower the company will produce soon. All new products undergo extensive research and testing before production.

Backbone of Production Line is Automatic Screw Machine. Pacemaker T gives outstanding performance as hydraulic medium in these machines as well as in Landis grinders and as a general lubricant!

Vol. 16, No. 1

Lubrication Engineering

tare
victor
george

The Navy, during World War II, had a way of complimenting an individual, ship or crew for a commendable effort with a simple, yet very meaningful message, TARE VICTOR GEORGE. In the parlance of an old salt, this was a formal acknowledgement of a job "well done," not a reference as to how one wanted his steak. This message certainly applies to this years' Joint Lubrication Conference under the able leadership of A. C. West, California Research Corporation—a former Navy man himself. To the New York Section (our hosts) also goes our praise for a splendid job in organizing arrangements that helped to make the Conference so successful.

The Conference Committee, composed of ASLE and ASME members, assembled a program that attracted more than 300 registrants to this meeting. At a time when there were a half dozen competing meetings in the same period of two weeks, this in itself speaks well of the attractive, timely and informative program. For the first time in Conference history, it was necessary to organize the program into seven sessions—consisting of twenty-six papers. The sessions covered the general subjects, Properties of Lubricants; Hydrodynamic Bearings; Metalworking; Lubrication for Advanced Flight Vehicles; Basic Friction and Wear; and Rolling Contact Fatigue and Friction. For a complete list of ASLE sponsored papers and a photo report of the conference see page 3.

A popular attraction of the meeting was a Social Hour arranged for by the New York Section.

To all of those who had a hand in the Conference, and particularly to the authors and their company management, without whom the Conference could not have been held, the Society expresses sincere appreciation.

A. B. Wilder
President

Reducing Leakage from Hydraulic Systems

by R. Q. Sharpe
Socony Mobil Oil Co. Inc.

A program to successfully control hydraulic leakage

The leakage of fluid from hydraulic systems can well be a costly and undesirable problem. In addition to the cost of the fluid which is lost, attendant costs of handling, janitor service, loss of damaged parts, and other factors must be considered.

While the control of leakage presents, at times, a problem which may not be easily or economically solved, many plants have found that a carefully conceived program of preventive maintenance provides a fully satisfactory answer. This involves a careful study of the hydraulic systems in the plant to determine which are the worst leakers. A study of the operating cycle and mechanical design then makes possible the development of a carefully planned preventive maintenance program. Such a program requires the training of the maintenance personnel in the design, use, limitations and operating requirements of the various elements required to reduce leakage from both moving and static joints. Experience has documented the fact that such programs can be effective and economical to install.

Other factors which must be considered in connection with leakage control are also discussed.

Many engineers connected with the steel industry are dealing with a definite increase in the use of hydraulic equipment in their operations. This situation is not unique with steel alone. An extremely high percentage of machine tools and other processing equipment found throughout industry today makes use of hydraulic actuation in one or more of its various forms.

The use of fluid power in industry has become prevalent because it provides substantial force, quick response, ready control of speed, a high degree of flexibility in layout and remote control, good dependability of operation in industries where unscheduled shut downs can be extremely expensive, and generally low maintenance costs. This discussion is directed particularly at one phase of the maintenance of hydraulic equipment; that of fluid leakage and how to control it.

Before further discussion, some insight into a few of the basic factors involving hydraulic equipment as used in steel mill operations may be of interest. The steel industry uses hydraulic units in the operation of combustion-control equipment, billet and coil handling, operational controls in the entry and discharge end of various rolling mills, presses and other similar applications. Since steel mills often introduce problems of low-temperature starting and fire hazards, all the various types of hydraulic fluids commonly available for industrial service are used. These include petroleum oils having properties to meet specific needs, fire-resistant fluids of the straight synthetic or water-glycol types, and in many instances, water-oil emulsions of one form or another. Each of these fluids has its own special properties, some of which influence the problems confronted in connection with leakage control.

Many people seem to feel that a high degree of leakage from large hydraulic systems operating at high pressures is an inevitable part of such operations, and they continue to live with this unhappy state of affairs. On the other hand, many plants have found that well conceived programs of leakage control have reduced fluid loss to a point where it no longer constitutes a major nuisance. If leakage is excessive, costs are increased. The cost of the fluid itself, which in the case of the fire-resistant products may be from two to seven times the cost of oil, is not the only factor. Related problems result as well, such as the fire hazard of large pools of oil collecting in pits or other depressions near the equipment, slippery floors, dirty equipment and the added cost of cleaning up the lost product. The cost of labor for storing and handling the extra fluid for make-up may be a very

Presented before the 14th ASLE Annual Meeting, Buffalo, New York, April, 1959.

significant item. In addition, it must be recognized that if the leaking fluid gets on finished strip sheets or other finished products, additional costly cleaning operations may be involved. There is also the fact that systems may be unexpectedly shut down through broken lines or hose connections which can cause a very severe loss in production.

When thinking in terms of the feasibility of installing a program for leakage control of hydraulic systems, a few fundamental decisions must be made. First, the decision to install a program must have full management backing. Second, a careful analysis of the hydraulic operating situation must be made by an interested and competent engineer. Third, the type and extent of the required program needs to be outlined and someone designated to administer the program who has been given sufficient authority to see that its various requirements are met. Fourth, the crew responsible for hydraulic maintenance must be educated as to the need and desirability of the program, and instructed in the proper use and repair of components affecting leakage. Fifth, suitable simple records must be kept of work to be scheduled, work done, when, and by whom.

In studying the plant situation with respect to leakage, certain basic areas must be examined:

1. The nature and general characteristics of the fluid or fluids in service. This would include a determination as to whether some modification of the type of fluid in service might be helpful. For example, leakage may often be reduced by introducing a higher viscosity of the type of product in service. Under some circumstances where long leakage paths are involved, the addition of polymeric additives has provided a transitory benefit, but simultaneously introduced the undesirable factor of viscosity instability. In general, it may be stated that a mere change in fluid will not solve the problem. Another factor is whether the fluid and packing materials in service are compatible. At present there is no single type of packing material fully satisfactory for all of the classes of hydraulic fluids being offered industry. For example, neoprene or Buna N are usually suitable for use with any high quality petroleum oil. They may normally be used in systems utilizing water-glycol systems, but are unsuited for systems containing phosphate-ester base materials. Therefore, changing a machine from one type of fluid to another may call for fundamental packing modifications. See Fig. 1.

2. Determination as to where the leakage is occuring and what its basic cause may be. Hydraulic systems have two general classes of joints through which the fluid may be lost. *Moving Joints* would include rod or ram packings, seals for valve stems, pump or fluid-motor shafts, and in some instances seals on pistons (which influence internal leakage). *Static Joints* from which leakage may occur include threaded joints, tubing fittings, O-rings, Quad-rings and other special forms of elastomers as well as sheet gasket material. In many kinds of equipment the most substantial fluid loss results from ruptured hoses or lines.

3. Review of maintenance practices. Is it being done on a "break-down" emergency basis, or on a planned preventive maintenance schedule? Is it being properly done? It is not uncommon to find plant personnel assigned to hydraulic system maintenance who are completely unfamiliar with the design and application requirements of pressure-actuated seals for hydraulic systems operating at pressures of 500 to 10,000 psi or even higher. Such men often are not aware of the true significance of the necessity of treating all hydraulic components, including seals and packings, as precision items. Even men who have been used for years on hydraulic maintenance often do a poor job because they have not been adequately trained in proper methods. A study of present maintenance practices should indicate the desirability of an adequate preventive-maintenance program in reducing hydraulic-system leakage. After completing these studies, management should assign an interested, well-qualified maintenance man to head up the program. He will probably be a supervisor trained in hydraulics. He should then be given special training in leakage control so he can properly educate and supervise the men with whom he is to work.

SEAL COMPOSITION	FLUID TYPE			
	OIL	FIRE RESISTANT FLUIDS		
		PHOSPHATE ESTER	WATER GLYCOL	WATER-OIL EMULSIONS
Neoprene	Yes	No	Yes	S.C.
Buna N	Yes	No	Yes	S.C.
Leather	Yes	No	No	S.C.
Butyl Rubber	No	Yes	Yes	No
PTFE	Yes (1)	Yes (1)	Yes (1)	Yes (1)
Silicone Compound	Yes (1)	Yes (1)	No	No

(1) Mechanical factors must be studied
S.C. = Special Consideration Required

Fig. 1. Packing compositions generally recommended for hydraulic fluids.

We have been pointing toward the need for adequate education in the maintenance handling of hydraulic-system leakage and it might be well to discuss briefly a few specific examples of why this is necessary.

In order to perform satisfactorily at high pressures, seals of *moving joints* of hydraulic systems are pressure-actuated and generally self-sealing. When proper seals are installed in properly designed grooves or packing glands, they do an adequate job without re-

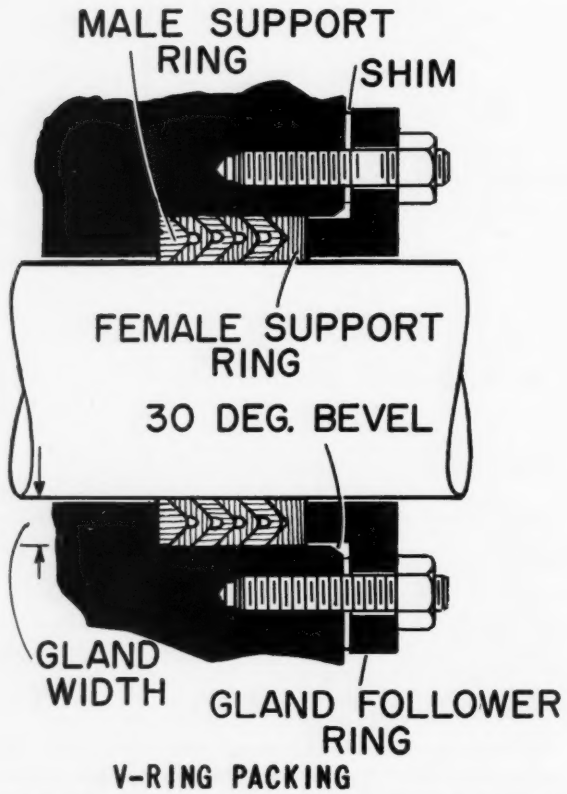


Fig. 2. V-ring seal. Gland follower ring is bolted metal to metal with a shim inserted to prevent the follower ring from exerting pressure on the sealing rings.

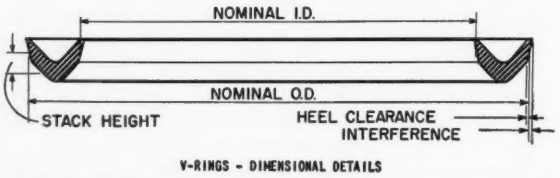


Fig. 3. The sides of a V-ring flare slightly so that when installed the pressure lips will be preloaded.

quiring frequent adjustment or tightening which, if engaged in, may actually destroy the packing and aggravate the problem. Fig. 2 illustrates a conventional V-ring packing used in connection with piston rods or rams on pistons and occasionally for rotating shafts. When installed in a suitably dimensioned gland, these V rings are open toward the high-pressure side and dimensioned to provide a degree of preloading. The fluid under pressure tends to spread the V open, thus increasing the tightness of the seal and its ability to stop leakage. The higher the pressure the tighter the seal. Althongh such molded seals do not appear to have high dimensional precision, the pre-load is actually determined by a radial interference dimension of from .02 to .035 inches. See Fig. 3. They must, therefore, be carefully installed to eliminate possible damage to the sealing lips and tightened lightly according to recommended practice. They must never be overtightened or the individual rings will become crushed and no longer be able to seal high pressures.

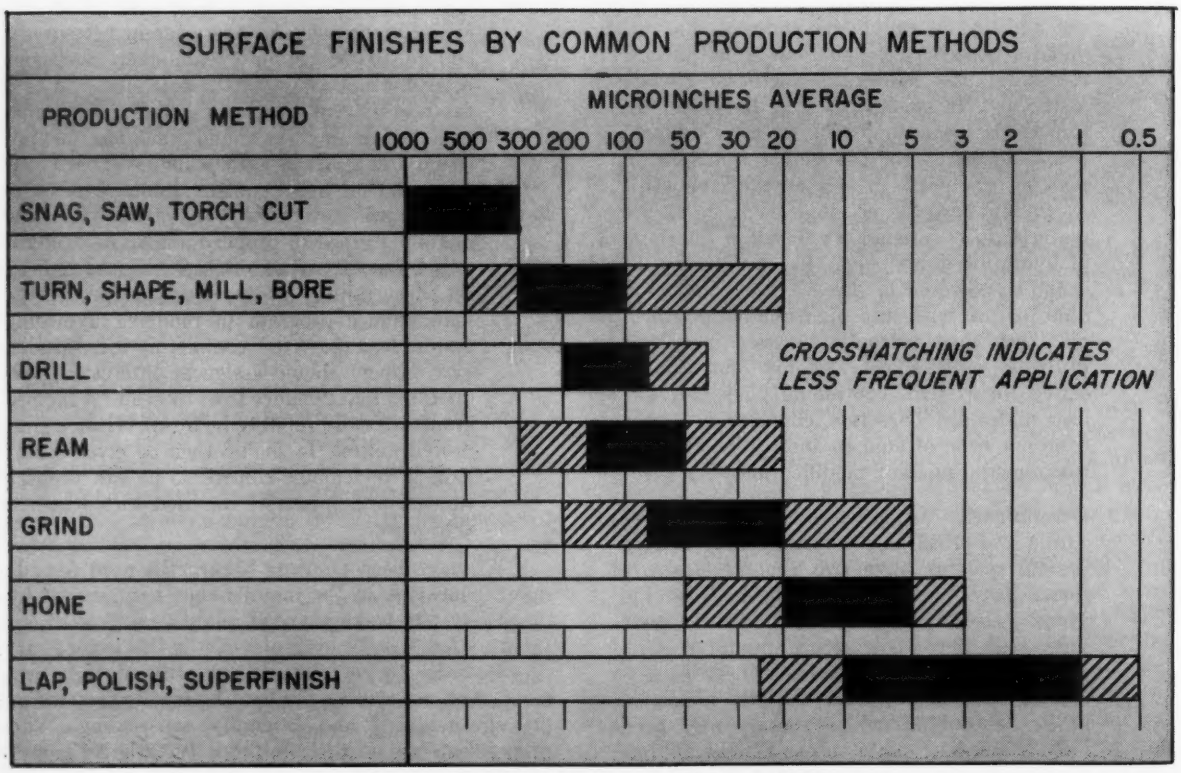


Fig. 4. Surface finishes by common production methods.

It cannot be expected that this or any other type of seal will stop leakage when used in connection with rods, rams, or cylinders having poor finish. Statistics indicate that a seal used on a surface having a finish of five to 20 micro inches will supply many times the life of one used on surfaces with a finish of even 100 to 200 micro inches. These differences are even more significant where homogeneous rubber seals are in service. Fig. 4 gives us some conception of what this should mean to the designer and the plant maintenance man in relation to normal machining methods. From this it will be observed that maximum seal life can be expected only where surfaces of rods, rams and cylinders are ground or honed. Care must be taken, therefore, to protect and maintain the smooth surfaces of rods, rams, shafts, and cylinders.

As another example, many seals are ruined prematurely when abrasive dirt is carried into the seal by the rod or ram. Effective means should be provided for protecting seals from such materials. This is particularly necessary where O-ring seals are used on reciprocating rods. Fig. 5 illustrates one type of metallic wiper ring found to be very effective in the protection of seals in such applications. Protective rings may be designed into new equipment or may be readily added to existing installations.

METALLIC ROD WIPER

Fig. 5. Wiper rings made of metal cones backed by rubber are sometimes used to keep harmful dirt out of the backing.

Again, in connection with *static joints,* it is necessary that the maintenance man have a clear understanding of the precautions that need to be taken in the proper selection, handling and installation of the elements influencing leakage.

The Joint Industry Conference Hydraulics Standard has been most helpful in influencing the increased use of SAE 1010 dead soft seamless steel tubing which provides flared joints that should not split or break. They have discouraged the use of threaded pipe and encouraged the welding of connections where black pipe must be used. Specific advantages are offered by the adoption of such recommendations. With American Standard tapered pipe threads, the tolerances may permit spiral leakage as illustrated in Fig. 6. Practically all of the standard tubing fittings used in industrial hydraulic equipment today utilize the

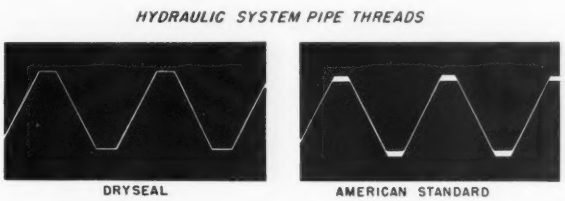


Fig. 6. Dry Seal and American Standard Pipe Threads. Note that the Dry Seal threads bottom against the root and thus prevent spiral leakage.

Dry Seal type of thread, which establishes contact between the root and tip of mating threads before the flanks come together. Spiral leakage, therefore, is eliminated. In existing installations where threaded pipe is used that is too small to weld satisfactorily, considerable advantage may be gained through the use of a simple special seal illustrated by Fig. 7. These are simple to install, requiring only that the surface of the pipe fitting, valve or cylinder body against which it is to be in contact be faced to a smooth surface. Many plants use these with excellent results since they are inexpensive, easy to install, and do not rely on thread compound to prevent leakage.

In the installation of either seamless tubing or threaded pipe, it is necessary to be fully aware of the damage that often results from system surges or vibration. Even the best joints will not long withstand the severe stresses imposed on them from high-frequency surges or abrupt halting or reversal of long columns of fluid flowing through the system at high speed. The sudden cut-off of a valve may start vibrations that will shake a machine weighing many tons. Shocks such as this and regular high-frequency vibration cause joints to fatigue, lines to rupture, and machines to be shut down with large fluid and production losses. Three preventive measures will greatly reduce the incidence of such troubles:

1. Modifying existing controls, or properly designing new systems to utilize to the utmost decelerating valves or other means of avoiding abrupt directional changes.

2. Circuit design or modification to reduce to a minimum high-frequency surges in the fluid stream. This is often aided materially through the installation of small accumulators to flatten out pressure peaks. See Fig. 8.
3. In any event, good operations and design dictates the use of an adequate number of proper clamps to prevent lines from moving.

Clamps may be of the purchased variety, or they may be made in the plant shop. Such supports should never be welded to lines since they may weaken the tubing wall as well as restrict line movement below a desirable minimum flexibility. Clamps made of wood blocks are highly satisfactory, since they provide a certain amount of resilience and low friction so they do not tend to wear through the tube wall. There have been numerous instances of U clamps or steel-strap clamps that caused a machine shutdown because they wore holes in high pressure lines. One important added precautionary note is the inspection of clamps. Since they are subjected to severe vibration, they tend to work loose. They must be inspected on a regular schedule and kept tight if they are to prevent line movement or breakage. Well-designed clamps have been known to work loose within a week's time on a large line in a baling-press system.

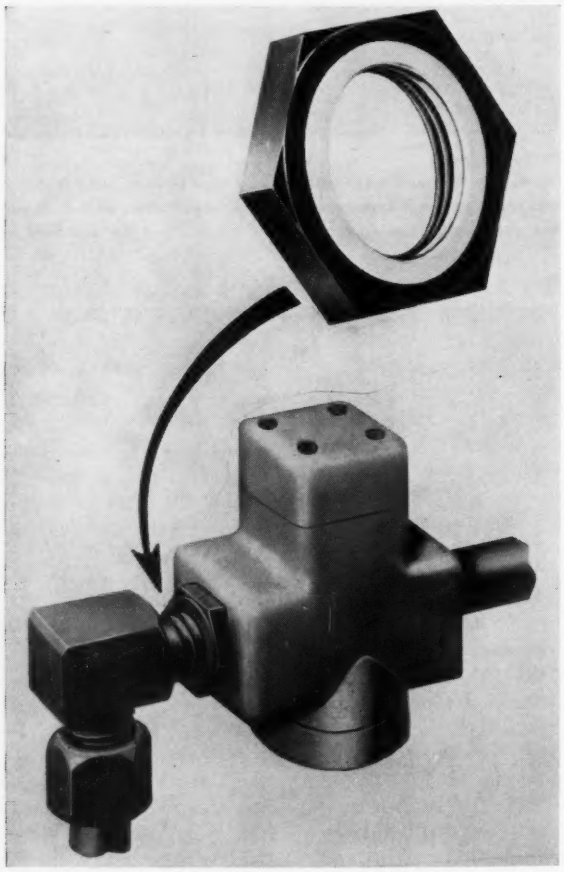


Fig. 7. A special nut with PTFE insert may be screwed up against the smooth base of a valve or cylinder body to prevent leakage in existing installations where threaded pipe is used.

Most hydraulic circuits employ some flexible hoses. Quality grades of high-pressure hoses available today are well designed for the service intended and will render long and satisfactory service if properly selected, installed and maintained. It must be recognized by the maintenance man that these are intended to move in service—that is why they are used—and they must be installed with that thought in mind. It is not uncommon, while standing beside hydraulic machines, to see hoses try to straight out as pressure surges hit them. These rapid, spasmodic movements occur frequently and may total hundreds of thousands of cycles within the life of a piece of hose. Yet, how many maintenance men honestly attempt to follow the simple installation instructions that mean the difference between long and satisfactory life or short life with premature failure and another unscheduled shutdown. The most significant precautions are summarized as follows:

1. Avoid installing hoses with short or double bends.
2. Avoid twisting of hoses when installing or tightening.
3. Avoid having short bends near hose fittings.
4. Hoses should not be used to support the weight of any other component.
5. Avoid having hoses in rubbing contact with any object—including other hoses.

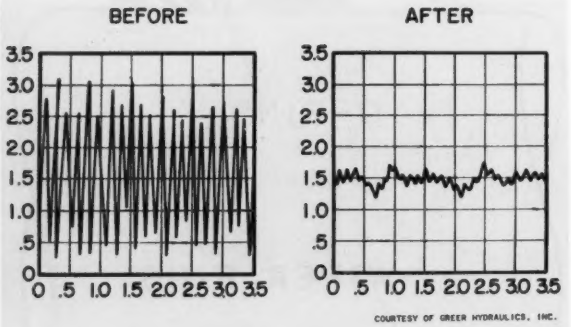


Fig. 8. Curves showing variations in accumulator pressure resulting from high frequency surges before and after circuit design modification.

Fluid loss due to hydraulic line breakage is such an important item that other influencing factors should be mentioned. The principal cause of breakage, which most often occurs at pipe or tubing fittings, is due to system characteristics which may subject joints to high or pulsating surge pressure and the resulting serious strains. The problem of surging can be minimized by modification of the equipment or its sequence of operation. It must be recognized that large lines, threaded, welded or with tubing fittings all

transmit shock from one system component to another. Adequate isolation of components by means of flexible hoses or swivel joints will help alleviate the mechanical vibration phase of this problem. This will also provide for expansion and contraction with temperature changes which may otherwise place a strain on rigid lines and connections.

The subject of static joints can hardly be left without some discussion of the other components that contribute to large losses of fluid if they are not properly handled. Most maintenance men are thoroughly versed in the types of flat-gasket materials available and their installation and care, so comments can be restricted to pressure-actuated seals.

The most common of the modern pressure-actuated seals for static joints are probably the O ring and the Quad ring. The Quad ring is less subject to rolling or twisting than the O ring. Each of these may be made of elastomers ranging from neoprene and Buna N to silicone and PTFE. Each material has its own significant properties, but since neoprene and Buna N are more common with oil, discussion will center about them. First, it must be understood that a suitable material must have good resilience, proper hardness to withstand mechanical factors of pressure and movement within its groove; compatibility with the fluid in service; chemical and oxidation stability suitable for the temperatures involved (in a hydraulic system usually below 200 F) and good mechanical stability. Fig. 9 shows that an O ring installed in a suitably designed and dimensioned groove is always under preload, so there can be no leakage, even when the system is not under pressure. On the other hand, a suitable O ring will satisfactorily hold and seal pressures up to 1000 psi without back-up washers and up to 5000 psi when suitably backed up to prevent extrusion as shown in Fig. 10.

It was mentioned earlier that the hydraulic maintenance man must be taught to recognize that he is dealing with precision components, even when dealing with molded packings and seals. Nowhere is that more true than with O rings. Fig. 11 shows the installation of an O ring in a typical static joint. It may be seen

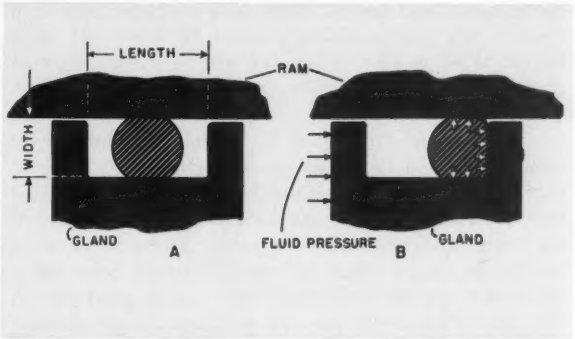


Fig. 10. When recommended clearance or pressure is exceeded, the O-ring tends to extrude into the clearance as shown at the top. Where extrusion is experienced, leather backup washers should be used.

Fig. 9. O-ring action. When pressure is applied to synthetic O-rings, they deform and transmit pressure equally in all directions. At A an O-ring is shown in a groove of exaggerated length. When fluid pressure is applied the O-ring moves against one wall of the groove as at B.

that the standard dimensions provide a minimum squeeze of 0.022 inch. This means that any appreciable scuffing or abrasion of the O ring when being installed in a static or a moving joint may prevent the ring from sealing. Seals must be stored and installed carefully according to the manufacturer's recommendations. Many seals and packings are ruined not only while being installed in a machine, but even

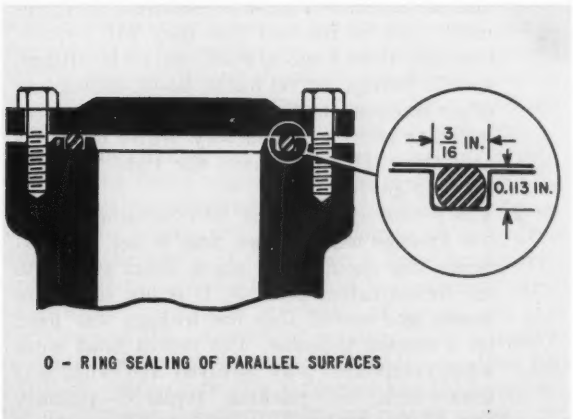


Fig. 11. Application of O-ring gasket to seal parallel surfaces.

before the maintenance man checks them out of the storeroom. These items are precisely manufactured and fragile in nature, yet often are placed on the shelves of shop storerooms with heavy gears, bearings or other machine parts stored on top of them. As a result they were either deformed or scuffed before ever being placed in service.

As previously mentioned, the piston rod, ram, shaft or cylinder in contact with a seal must have a finish of five to 20 micro inches to provide good service. A rusted cylinder or ram obviously would not have such a finish. Yet such components have been seen lying in storerooms badly rusted either in transit or storage, waiting for some unsuspecting maintenance man to come along and install them in a machine and then wonder why his packing started to wear out in a hurry. What a pity, when the use of a suitable rust preventive by the builder, or by your storekeeper, would prevent it.

Perhaps at this point it is understandable why education is included as an important and integral part of a program to reduce leakage in a plant. Just because a man has been packing pumps or has worked on the pipe-fitting crew for many years is no valid reason to assume that he can be turned loose on a hydraulic system and expected to go a good job. A few for instances of what can and does happen follow: A V-ring packing with the apex of the V toward the pressure; V-ring packings over-tightened and crushed to the point they were acting as a jam packing; radial-lip type or O-ring seals ruined by dragging them over a threaded or keyed shaft that was rough with burrs; pipes or lines that break regularly because of vibration; hoses that rupture in a matter of weeks where they should be lasting months or years—because of repeated errors in their installation. These are the costly and tragic results of thinking that nothing can be done about hydraulic-system leakage.

Earlier it was indicated that a program was needed in order to successfully control hydraulic leakage. This program had to have management backing. Furthermore, a study of existing conditions must be made, and a competent man placed in charge. There are other facets that this program must embody after these preliminary items are handled:

1. The cooperation of the Purchasing Department and the Storeroom must be established. Agreement must be reached that they will requisition only those kinds of packings, seals, fittings, special fittings, swivel joints, hoses, tubing and other components that the supervisor has selected to effect a satisfactory degree of standardization. He must have the right material for the right job.
2. The record system must be established. Since the average maintenance man is not a statistician this should be a check chart system to the fullest extent possible. It is not enough to report and record that the leakage was fixed on a certain machine. The record must show what component was involved and what was done—such as, packing replaced—primary ram, hose replaced in coil-upender circuit, packing replaced—triplex-plunger pump, etc.

   In order to have a record system that may be used for pre-planned maintenance, a suitable system of inspection must be established. Experience has indicated that this can usually be well done by selected hydraulic maintenance mechanics or the supervisor, or both.
3. The planned maintenance must be worked out with the Operating or Production Departments so there will be a minimum of interruption of operating facilities. Much of this work can be done during scheduled interruptions in operations. Statistics show that carefully planned pre-scheduled preventive maintenance actually reduces maintenance costs and increases production, even in plants that run 24 hours a day, seven days a week.
4. Establish clinics for the information and education of the hydraulic maintenance crew. These should preferably be held in the plant during regular working hours and the men paid while attending them. The men must be trained not only in why these elements are designed as they are, but also to recognize and appreciate the benefit to them and the over-all company operation to install and maintain them carefully and correctly. Even when they are called out to do emergency breakdown work, they usually will have time to do the job right. It may take a few minutes more, but it will usually last much longer.

   This job of training is an important one, and your supervisor can call on many sources for help. While not all suppliers are equipped to do so, many of the suppliers of packings, seals, fittings, hoses, hydraulic components and fluids have engineers and clinic material of this kind. For example, the author's Company has done considerable work in this regard with users of our products.
5. The system, once set up, must become a continuing program and one that is reviewed regularly, the same as any significant part of your operation.

Is such a program profitable? One plant extended the packing life of a battery of triplex plunger pumps handling soluble oil by a simple change in their setup following recognized basic principles. Another metal working plant reduced production losses and, following a period of expansion, handled 2½ times as many hydraulic machines with the same maintenance crew. Another plant in the plastic-molding business stopped practically all of their unscheduled shutdowns by a well-conceived program of inspection and planned replacement of troublesome elements. An automobile parts plant discovered that approximately seventy per cent of their leakage came from a small percentage of their machines. By concentrating on these they reduced their over-all leakage loss by 50 per cent. Would you like to enjoy similar benefits? Then install a preventive maintenance program for hydraulic-leakage control.

In the manufacture of servo-controlled milling machines, several problems arise having to do with the behavior of sliding surfaces. The principle problem is the large and variable friction often encountered which causes continual changes in the servo properties of the machine. Curiously enough, it is not the desire of the designer to eliminate the friction. His goal is to bring it within the limits where it contributes to the stability of the system without in any way inhibiting the action or reducing the accuracy of the positioning.

Many design features have been incorporated into such machines in an attempt to realize the ideal and some research has been done to provide background material for the use of the designer in reaching his goal. A number of interesting friction control techniques have been evolved and a large number of oils eliminated from the acceptable list. A relatively simple method of evaluation has been devised for the latter procedure. A testing method has been set up for comparing oils and compiling data upon which to base selection.

A Survey of Way Lubrication Problems Peculiar To Servo-Controlled Machine Tools

by R. K. Sedgwick
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Milwaukee, Wisconsin

THE GENERAL DESIGN PROBLEM

A servo-controlled machine, as presently developed for the utilization of tape or punched card input consists of a large number of devices chained together (more or less in series) whereby a very small signal generated in the reading mechanism is magnified and transformed through various energy forms until it results in a force applied to one or more of the machine slides so as to cause them to move. It is desirable to have the whole system so arranged that the velocity of the resultant motion is nearly proportional to the magnitude of the signal at some stage of the amplification. This requires that the velocity resulting from a given signal strength this time must be nearly the same as it was last time, if consistent performance is to be obtained. Another requirement is that the force required to initiate motion must not be unduly large, lest immediately after breakaway a sudden and unwanted acceleration should result. Such sudden accelerations produce the typically jumpy action of the sticky slide and they often produce large excursions of the servo system before it settles down. In addition, when such a jump occurs just before the desired final position is attained, an overshoot is almost inevitable.

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The implication of the foregoing is that the designer cannot simply use large forces to overcome large friction but must reduce the friction, and particularly the "stiction" (as it is frequently referred to in the machine tool industry), to values that the servo system can tolerate. It is desirable to reduce friction to where the principal force required to produce motion is that required to overcome inertia until the velocity is increased to a point where friction is needed for stabilization. This last qualification explains why the absolute elimination of friction would not be desirable. Servo systems need a certain amount of damping and the way it works out is that the force produced by the damping means should be proportional to the velocity. In other words, pure viscous drag would be the best kind of damping that could be had.

A slide running on an oil film almost invariably exhibits the usual characteristic force-velocity function—namely, a high initial force causing break-loose, followed by a drop and gradual sloping off as hydrodynamic effect sets in. The general slope is negative and the steepness and curvature of the curve are variables depending on the properties of the oil and the surfaces and the intensity of loading. That intensity of loading is irrelevant is one of those fictions that die hard. Of course, intensity influences the thickness of the oil film—and, consequently, the rate of sheer.

Fig. 1 illustrates two curves having as unlike

properties as could be found—and, in fact, one of them has not been found yet. The curve with the sharp hook is typical of the usual slide motion where the force builds up until motion begins, then drops sharply and tapers off with increase in velocity. The line with positive slope represents the ideal from the servo standpoint where the resistance is zero at zero velocity and rises linearly throughout the velocity range. This, obviously, cannot be attained without radical changes in mechanism, oil, or both.

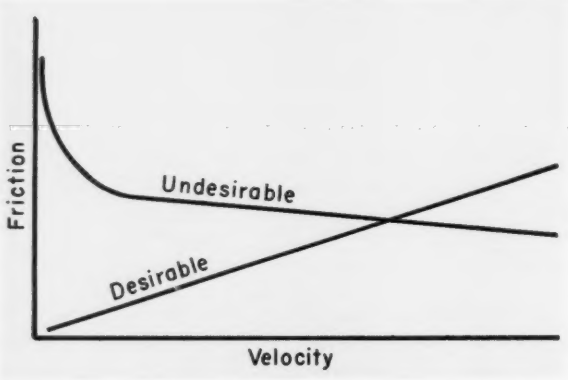

Fig. 1. Curves showing desirable and undesirable friction-velocity characteristics.

TESTS ON ACTUAL MILLING MACHINES

Initial stages of the current investigation of oils and ways were made on actual machines during the debugging period. Fig. 2 shows a typical test set-up in which a hydraulic cylinder is attached to the bed of the machine and its piston rod attached to the slide by means of a load cell. The leads from the load cell are connected to an amplifier and the output of the amplifier to a recording device, generally of the oscillograph type. The cylinder was controlled by a servo valve so that very slow motions could be obtained and there was enough elasticity in the cylinder so that any tendency to shudder was immediately apparent. This machine was lubricated by an intermittent application device and the curve of Fig. 3 is typical. This curve is not plotted force vs. velocity but force vs. time. The rising line at the beginning shows the force rising as the pressure was slowly built up by tightening the relief valve until breakloose occurred. At this point, the resistance dropped in the usual way until a state of near equilibrium was reached whereupon this was disturbed by the operation of the lubricating device. Notice that at each subsequent operation of the device the friction dropped off slightly, only to build up again as the oil settled down to approximately its equilibrium film thickness. This much variation in what would otherwise be a steady state situation brought a fair amount of criticism from the people responsible for the design of the servo system and led to the investigation of other methods of oil application.

THE SPECIALIZED TESTING DEVICE

The work done on the erecting floor indicated that much more could be learned if equipment were

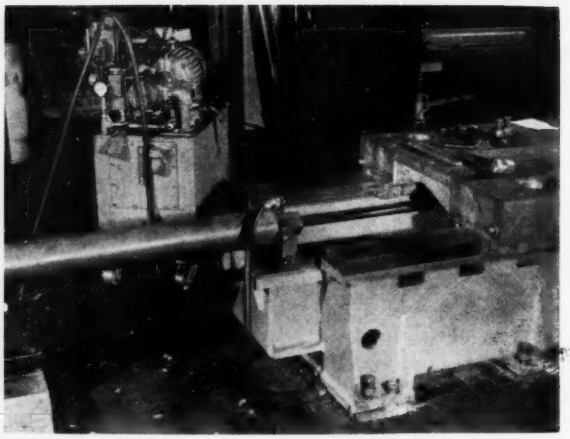

Fig. 2. Test set-up on milling machine slide to measure friction directly.

set up especially for this purpose with the result that a complete testing rig was built up and installed away from the production area and program laid out to learn how different oils reacted to changes in sliding velocity. Fig. 4 shows the equipment as installed. At the left is a standard feed slide having hardened and ground steel ways. The platen carrying the loading weights has two plastic-faced slipper pads resting on the steel ways. Each slipper has a conventional oil groove pattern and both are supplied with oil by a one shot lubricator mounted on the platen. At the near right is a hydraulic system providing for rate control and electrically actuated reversal. At the extreme right is the instrument wagon carrying the power supplies, amplifiers and oscillograph. The piston rod is fastened to the platen by the load cell as before but this load cell is smaller with a one ton rating.

This apparatus was run with a large number of oils with the platen cycled both automatically and single stroking. Each oil was placed in the one shot lubricator and fed to the platen by a shot at the beginning of the return stroke. Each stroke was then started with a fresh shot of oil that had partly spread out during the previous return stroke. Working strokes were made at a variety of speeds from about five inches per minute to over one hundred. The forces required to produce each stroke were recorded on the oscillograph while the speeds were measured by a stop watch and marked on the oscillograph chart by hand.

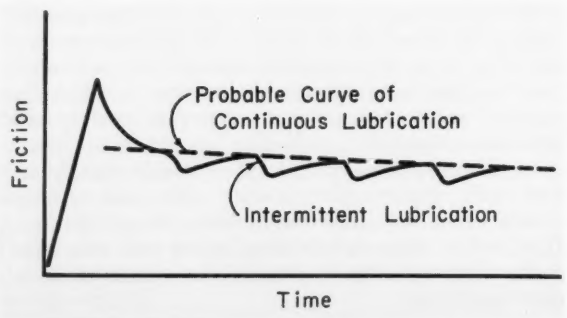

Fig. 3. Curve showing friction-time variation with intermittent lubrication.

When the data had been collected, a program of evaluation was begun. Several criteria of judgment for oils were set up, to wit:

1. Any oil which showed a ratio of maximum to minimum force of ten or more was rejected at once.
2. Any oil which allowed the platen to shudder noticeably was rejected.
3. Any oil that was noticeably poisonous was rejected. (Some were).
4. Any oil that produced a force at breakaway that was excessively high was rejected.

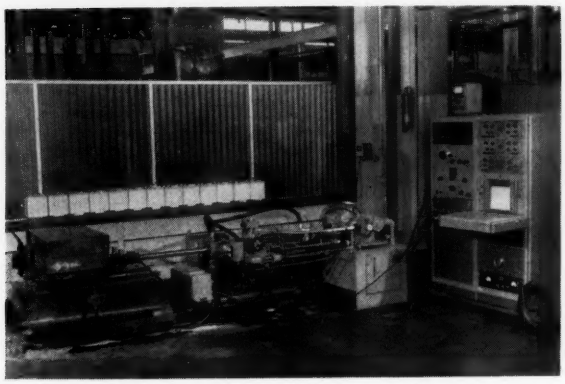

Fig. 4. General view of automatic cycle oil testing device.

After all this rejecting had taken place, there were just four oils left. One was a well known commercial oil and the other three were straight from the lab and known by code numbers only.

Fig. 5 illustrates the force-velocity characteristics obtained from several representative oils by the above method. The uppermost and the lowermost curve are of the same oil with two different loadings, 14.7 psi and 29.8 psi. Notice that not only are the friction values different (which is to be expected) but the shape of the curves is different too. The total variation is much more for the low-intensity loading than for the high. This oil would have been rejected out of hand for the low-intensity case because of its extreme variation if it were not for the high total friction exhibited in the high-intensity case. As it was, the latter feature threw it out even more conclusively.

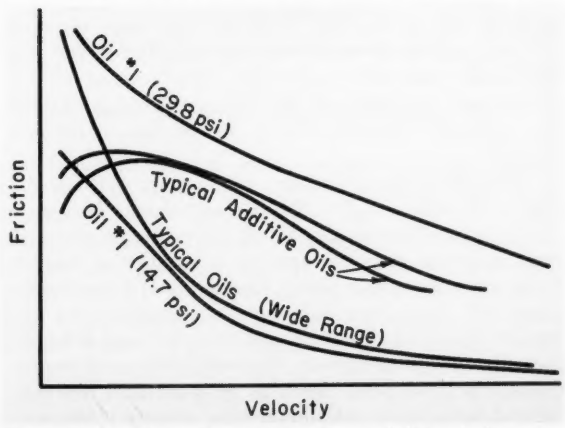

Fig. 5. Friction-velocity characteristics of several different oils, measured by the automatic cycle testing device.

The intermediate curve with the strongly hyperbolic shape is typical of several oils in the program but is the worst of the lot. Its highest friction force is as high as any of the oils tested, while its lowest is almost as low as the lowest. It was rejected for its high initial friction as well as for having too much range.

The two curves with the initial downward concavity and later inflection are typical of a series of oils that are doped up with additives. These do quite well in the servo type machines and are now used extensively. Their total variation is generally not over two and a half to one, while their highest breakaway loads are actually lower than the loads encountered at higher velocities. This phenomenon was new to us and we were inclined to question it until it appeared persistently with several oils and always of the additive type. As explained above, this particular property is desirable for our purpose because it has the proper damping quality, although not in the proper amount.

If it is recalled that the ideal oil would be one with a perfectly linear force-speed curve with positive slope, it can be seen that a few things need to be done to those oils to meet the ideal. Firstly, the low-speed end of the curve should be brought still lower. Secondly, the high-speed end should be raised. Thirdly, the whole curve should be straightened.

The first objective, reducing the initial friction, can be accomplished in part by the use of a hydrostatic system which is capable of maintaining an oil film of reasonable thickness during long periods of standstill. This produces a continuous outflow from the ways and makes some sort of reclamation almost mandatory.

The second objective, raising the high speed resistance, could be accomplished by using oils of extremely high viscosity so that the viscous drag would have reasonably high values.

The third problem, straightening out the curve, means that some arrangement must be used to maintain as nearly uniform a film thickness as is possible. This is difficult, particularly with very viscous oils, because as soon as motion starts a certain amount of hydrodynamic effect sets in and the film is thickened. This reduces the shear rate—and, consequently the friction. If the film thickness cannot be kept down to that obtained at low velocities, perhaps a solution would be to stabilize the film at the level corresponding to high speed and somehow prevent the usual thinning out at low speeds. This would mean artificial methods must be used to prevent settling during low-speed operation.

One of the classic methods of accomplishing this is the use of rollers in combination with plain ways. Experiments with this construction have indicated that over reasonable values of speed range, a substantially flat characteristic can be achieved. In other words, there is almost no change in friction over the speed range. This combination has resulted in coefficients of friction as low as 1.25 per cent but at this level the friction was so low that little stabilizing effect was obtainable so the roller load was backed off to bring the friction up to about four per cent. During these adjustments, the change in oil film thickness is easily measured. *(Con't on p. 31)*

The purpose of the test is the rapid evaluation of the resistance of lubricants to oxidation and sludge formation under dynamic equilibrium condition, using greatly accelerated test temperatures and oxygen pressures in the presence of liquid water and catalytically active metals. The Rotary Bomb Oxidation Test (RBOT) was originally developed for refinery control testing of rust and oxygen inhibited turbine oils and measured life in terms of length of induction period as determined by the drop in test pressure. In its modified form the test evaluates the oxidation and hydrolytic stability, inhibitor susceptibility, corrosivity to metals and resistance to sludge formation of all types of lubricants. It can also determine the mutual compatibility of new and used oils and the remaining life expectancy of oils from service.

Tests can be completed in one working day and thus save considerable time and labor. Oil stability is expressed in terms of minutes instead of hours, days or weeks and test results show good reproducibility and correlation with service performance. The tests are simple to run and have demonstrated their value in routine and research work on lubricants.

The Rotary Bomb Oxidation Test

by George H. von Fuchs

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With the advent of rust and oxidation inhibited turbing oil (1) (2) and of additive type engine lubricants just twenty years ago, a new era in lubrication began. Sludging, rusting and bearing corrosion and wear no longer had to be accepted and tolerated as unavoidable evils. The new inhibited oils were oxidation stable permanent lubricants, cooling agents, sealants and transmitters of power and also protected the machinery in which they were used. (3)

These new lubricants required the development of new methods of evaluation such as the well known turbine oil stability test (TOST) (2) (4) in which oils are tested at 95 C in presence of oxygen, water and catalytically active metals at atmospheric pressure. When in this test sludging and rusting are observed as test criteria, oils are rated according to their performance in service. In the TOST some oils sludge after a few weeks of testing time while others remain essentially unchanged for over three months (2000 hours) (5). The test can not be speeded up by raising the test temperature because the water would evaporate and without water the oxidation products would be quite different from the ones normally encountered in service.

Presented before the 14th ASLE Annual Meeting, Buffalo, New York, April, 1959.

ROTARY BOMB OXIDATION TESTS

Since due to its long duration the TOST proved impractical for plant control work, the rotary bomb test was developed for this purpose in 1940, but was published only in 1952. (6) In England a modified version of the test was developed. (7)

Both of the above tests used stainless steel bombs with glass liner containing copper and iron catalyst coils, 60 ml oil and 20 ml water and were charged with 90 psig 0_2 at room temperature. During the test the bombs were subjected to 150 C and rotated axially at 100 rpm with the axis 30 from the horizontal until the pressure dropped 25 lb below the maximum reached.

According to a February 1953 report of the Institute of Petroleum (8) "The Rotary Bomb Test generally referred to as the Wood River Bomb test has been in use in various forms in a number of laboratories for some years past." Under the test conditions described above four reference oils supplied by the British Admiralty showed induction periods from 60 minutes to 500 minutes. "Repeatability and reproducibility have been found to be good and are considered sufficiently satisfactory for checking the continuity of standard of supplies of any particular oil of this type."

At a meeting of the ABC (American, British and Canadian) Navies Lubricants Advisory Committee in October 1955, the British proposed the Modified RBOT as a short term acceptance test for rust and oxidation inhibited turbine oils.

The original (Wood River) version of the RBOT (6) used an oil bath as a heating medium while the BP version used aluminum block heating. Due to the poor heat conductivity of stainless steel, the heating up period (i.e. the time required to reach maximum pressure) was over one hour with an oil bath and nearly two hours with aluminum block heating. This made it necessary to apply a correction factor to the test results by deducting half of the heating up period from the overall testing time. This seriously interfered with testing uninhibited oils or oils from service which had relatively short but still adequate life expectancy, because such oils often did not reach maximum pressure before the break.

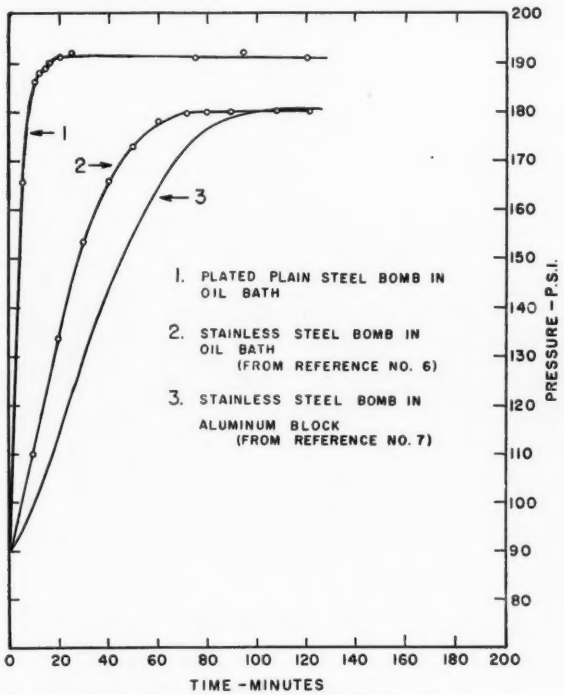

Fig. 1. Rotary bomb oxidation test time-pressure curves.

THE NEW ROTARY BOMB OXIDATION TEST

The present bomb test is an improved and simplified version of the published equipment and procedure (6). The bombs proper are made of plated plain steel (9), instead of stainless, which greatly improved heat transfer. (Fig. 1) The iron catalyst coil is left out and the copper catalyst coil built into the glass liner where it is chemically cleaned and then re-used in situ. (Fig. 2) This saves time, material and labor. The electrically heated oil bath which can be made to hold and rotate one, two or four bombs simultaneously (Figs. 3 & 4) is equipped with magnetic drive and various automatic control devices. Recording pressure gages are also successfully used. (Figs. 5 & 6) The aluminum block heating method for rotating four test bombs simultaneously (7) of which several units were made here in the U. S. and which turned out to be too expensive to build, was abandoned in favor of the improved oil bath heating method. As heating oil a heavy bright stock is satisfactory. Typical properties of such an oil are: Flash 710 F, vis. at 100 F = 3545 sec., vis. at 210 F = 198 sec., V.I. = 100, color 3.5

Fig. 2. Rotary bomb and accessories.

The test procedure is briefly as follows: 50g of oil is weighed into the glass liner, containing three m of 14 gage chemically cleaned copper wire. 5g of water is added and the liner placed in the bomb (also containing 5g of water to improve heat transfer). The

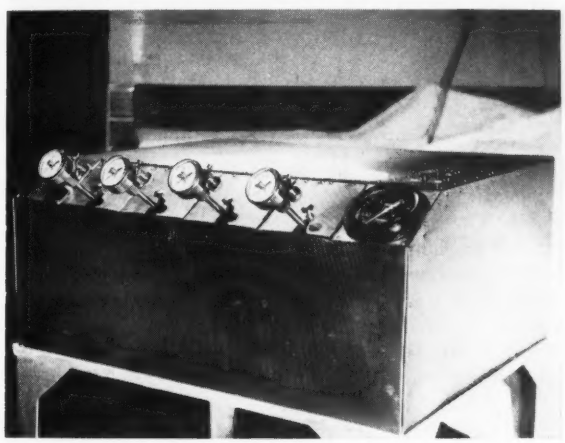

Fig. 3. RBOT apparatus for one bomb.

bomb is closed with a small hand wrench, flushed with oxygen and pressurized to 90 lb at 25 C. The bomb is then slid into the rotating device of the preheated (150 C or 140 C ± 0.1 C) oil bath. Pressure readings are taken at five or ten minute intervals. The pressure first rises, reaches a maximum within 15 minutes, levelling off at 192 lb (170 at 140 C). This pressure closely approaches the calculated maximum values of 196.7 lb at 150 C (and 173.8 lb at 140 C). When the pressure drops 25 lb below the maximum reached (corresponding to an oil neutralization value of about 0.5) the test is terminated, the bomb removed from the oil bath and immersed into a can of low viscosity oil for primary cooling and washing off of the bath oil. It is then immersed into cold tap water

for one minute and after releasing the remaining pressure (about 60 lb) can be opened. Washing, cooling and opening takes less than three minutes.

For greater precision, the bomb proper is immersed in a thermostatically controlled water bath at 25 C and kept here for 15 minutes to reach temperature equilibrium conditions. This procedure also serves to detect leaks due to a faulty gasket. For routine work the use of a water bath is not necessary. If a water bath is used, the bomb should be freed of adhering water before it is immersed in the hot oil bath to avoid sputtering. An airblast is satisfactory for this purpose.

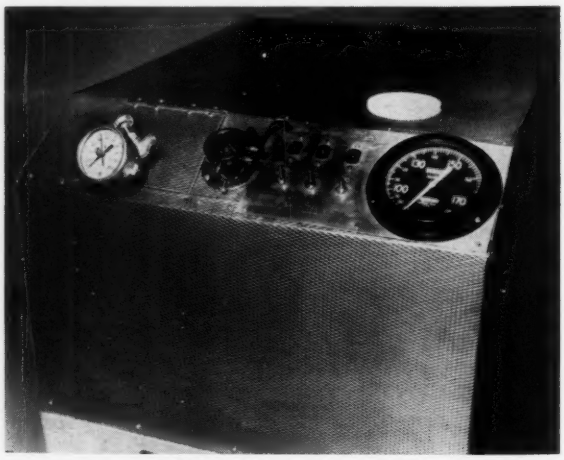

Fig. 4. RBOT apparatus for four bombs.

The inside of the bomb including the stem is washed with hot detergent solution and rinsed with water. The glass liner containing the catalyst coil is washed on the inside with benzene, acetone and chloroform to remove oil, water and sludge, then washed inside and out with hot detergent solution, rinsed briefly on the inside with a warm aqueous solution of sodium cyanide (to brighten the copper surface) and after rinsing with water, is ready for re-use.

Typical test values:

	RBOT at 150 C	RBOT at 140 C	TOST at 95 C
1 B (new oil)	152 minutes	288 minutes	20 weeks
2 B (1 B used)	55 minutes	99 minutes	4 weeks

The sodium cyanide solution is best prepared by placing a few grams of powdered NaCN in the glass liner and adding hot tap water. Some oil additives react with the copper to form deposits which are difficult to remove by NaCN alone. In such cases a rinse with 1:1 diluted nitric acid may be needed. If this practice is followed, great care must be taken to rinse the glass liner with water to prevent mixing of HNO_3 with NaCN. Also nitric acid attacks and dissolves metallic copper. Since the catalytic action of the copper depends on the ratio of the area of copper surface to oil volume, the copper catalyst coil must be replaced after losing ten per cent of its original weight.

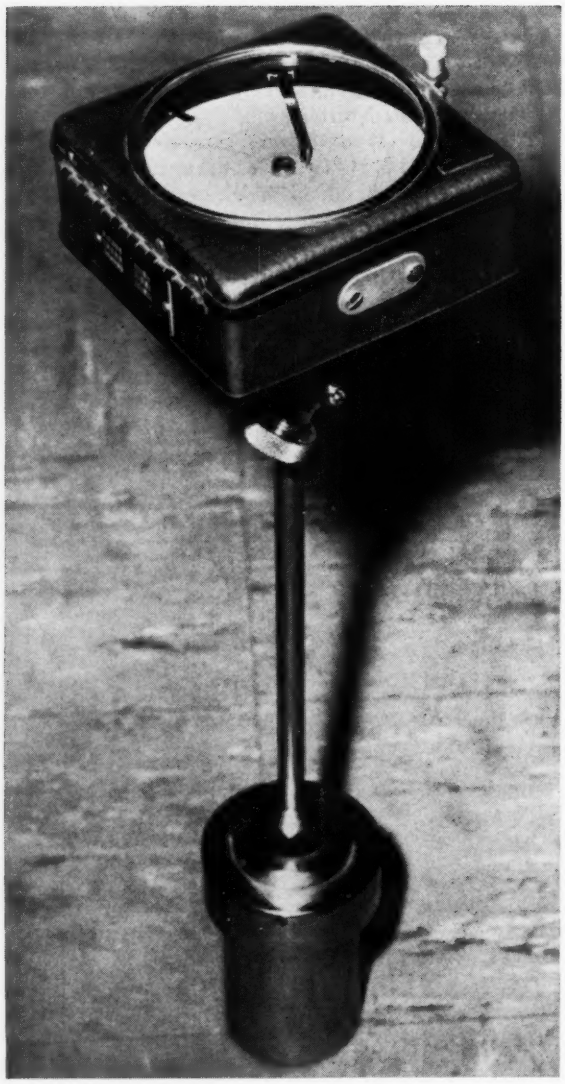

Fig. 5. Rotary bomb with recording gage.

SLUDGE FORMATION

The first commercially successful rust and oxidation inhibited turbine oils contained a long hydrocarbon chain alkylated succinic acid (ASA) and di-tert. butyl para cresol (DBPC) as additives. This line of oils had TOST lives of over 1000 hours. The U. S. Navy's 2190T oil was their best known prototype.

By the time ASTM published the TOST procedure (10) it was common practice to express oil life by the number of hours it took to reach a neutralization value of 2.0 and was so stated in the published method. This turned out to be rather unfortunate because when other oil companies entered the field, their aim was to make oils which had the longest possible TOST lives expressed in hours to reach a neutralization value of 2.0, irrespectively of sludge and/or rust formation in the test. As it happened, the amine type anti-oxidants chosen to accomplish this aim as well as some of the rust inhibitors used, effectively prevented the development of a high neutralization value in the oil, but caused severe sludging

and rusting. While this situation was soon pointed out, (11) nothing was done about it until complaints from service finally caused abandonment of the use of amine type anti-oxidants in turbine and hydraulic oils. It is gratifying to note here that the ASTM Committee in charge of method D 943 (TOST) is now considering a revision of the test criteria to include sludging and rusting as well as a lowered neutralization value for termination of the test.

While the close correlation between RBOT induction periods and TOST oil lives was pointed out earlier (6) it has since been shown that the sludge formation experienced with certain oils in the TOST is also duplicated in the RBOT. Oils containing amine type anti-oxidants which often have rather long induction periods, invariably form sludge much before the break. This can be easily shown by removing the bomb from the heating bath one or two hours after the start of the test, cooling and opening it as already described and inspecting the contents of the glass liner for sludge. Rapid cooling of plated steel bombs is perfectly safe, while due to their poor heat transfer characteristics, this cannot be said for bombs made of stainless steel.

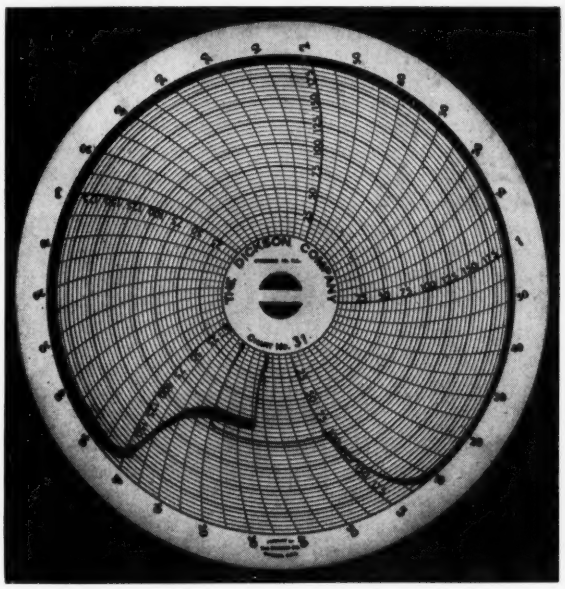

Fig. 6. Chart for recording pressure gage (actual size=4½ in.) showing RBOT on oil containing 0.25 per cent DBPC and 0.04 per cent ASA (See Table II on page 98 of Reference No. 5) Pressure curve starts at five hours and reads counter-clock-wise. Break is at 244 minutes.

CASE HISTORIES OF SLUDGING IN SERVICE

The lubricating system of a new turbine generator installed at a large Midwestern Utility developed sludge soon after starting. Sludging was so severe that it plugged screens on the oil-return lines. Except for darkening, the oil which was known to contain an amine type anti-oxidant, showed no sign of breakdown and had a long oxidation test life in ASTM—D 943 (time to reach a neutralization value of 2.0) and also in the Rotary Bomb Oxidation Test (time to reach a pressure drop of 25 lb). However, in both tests severe sludging could be observed well within the induction period. The oil was removed, the system cleaned with a turbine flushing oil and a new oil fill containing di-tert. butyl para cresol as anti-oxidant and an alkylated succinic acid as rust inhibitor, was installed. For the past four years the oil system operated free of sludge.

An inhibited turbine lubricant at a power generating station in Western New York required frequent filtering to remove suspended sludge. This entailed considerable labor and the addition of make-up oil to replace losses encountered in the reclaiming operation. The oil itself had no measurable neutralization value and showed a remarkably long bomb life. The trouble was traced to the amine type anti-oxidant contained in the oil. When a freshly filtered sample of the oil from service was tested in the RBOT, and the test terminated after two hours, i.e. much before the break, the bomb liner was found to contain a large amount of sludge and so did the unoxidized filtered oil after two weeks storage on the laboratory shelf.

From the above it is quite evident that a long induction period gives no assurance of good service performance unless it can also be shown that the oil remains sludge free at least during the first half of its induction period. For routine testing it is often sufficient to run the test for two hours and then open up the bomb to check for sludge.

SHORT TERM OXIDATION TESTS

In view of the long testing times encountered in Method D 943 (TOST), both the U. S. Navy and the Edison Electric Institute Prime Movers Committee Power Station Chemists Subcommittee have independently expressed their desire for ASTM to develop a short term oxidation test, preferably one which can be completed within one working day. A number of such tests were proposed, several of them studied cooperatively and one STOP even published for information. (12) However, this test did not gain acceptance here or abroad and now the search seems to be narrowed down to the RBOT as the only promising short term test. Nine members of the ASTM Turbine oil Oxidation committee have rotary bomb test equipment and six of them have participated in cooperative tests which however, so far were largely limited to determining the induction period of new and used turbine oils. In view of the proposal, to include sludging and rusting as test criteria of D 943 (TOST) in future work of the committee these criteria will probably be included in the RBOB as well.

OXIDATION STABILITY VS. INHIBITOR SUSCEPTIBILITY

Rust and oxidation inhibited lubricants are composed of a base oil containing several functional additives. These components must be selected in such a way that they can work together harmoniously without interfering with each others duties. (5) One important criterion of base oils is their susceptibility to anti-oxidants. (13) It is well known that some base oils will respond to anti-oxidants much better than others. This difference is due to small amounts of non-hydrocarbon impurities, which are either originally

present or which readily form from certain unstable oil constituents. The effective removal of these contaminants is or at least should be the main purpose of refining. The RBOT is ideally suited to check the degree of refining by testing oils in the presence of known quantities of a proven anti-oxidant. However, if the refining method used is not sufficiently selective, there is the danger of over-refining i.e. removal of valuable aromatic oil constituents along with the undesirable impurities. It has been shown that certain of these aromatics act as natural inhibitors (13) and that the inherent stability of base oils depends on the relative proportion of these good aromatics vs. the undesirable impurities.

The RBOT is also being successfully applied to test base oil stability. When testing uninhibited oils and certain inhibited oils it was found preferable to reduce the test temperature to 140 C. The following experiments were conducted at the lower temperature. To illustrate the effect of naturally occurring corrosive impurities, an oil high in aromatic content was tested in the RBOT in the presence of metallic copper both with and without water in the bomb liner. In the dry test the oil had an induction period of 300 minutes but when water was present the induction period dropped to less than 50 minutes. This is particularly significant since in most applications, lubricants are operated in the presence of at least a small amount of water and a high temperature test made at atmospheric pressure (in absence of water) can give misleading results.

In another experiment base oil was selectively refined to remove only the corrosive contaminants but not the aromatic oil constituents or the unstable impurities. This oil gave a long induction period in presence of water (160 minutes) but when the test was repeated in a dry bomb, the induction period dropped to 70 minutes. In the wet test apparently the peroxides (5), (14), (15), formed as the primary oxidation products of the unstable oil impurities were concentrated in the water phase while in the dry test they remain in the oil phase.

In a third experiment the base oil was selectively refined so as to remove both the corrosive contaminants and the easily oxidizable oil constituents but to retain most of the aromatics. In the RBOT this oil had induction periods of over 200 minutes both in the presence and absence of water.

The oil produced in the third experiment represents an ideal base stock because it is non-corrosive to and not affected by metallic copper, has excellent inhibitor response as well as a good oxidation stability of its own which is due to the optimum aromatic content (13) of this oil.

HYDROLYTIC STABILITY

Many oil additives and also some synthetic base stocks which perform quite well at elevated temperatures in absence of water, behave rather poorly when water is present. This behaviour is commonly attributed to their lack of hydrolytic stability. Esters are particularly water sensitive but tests at atmospheric pressure are usually too time consuming to be practical. For instance one ester type rust inhibitor lasts for several hundred hours in the TOST before rusting starts. Since the normal life expectancy of rust and oxidation inhibited industrial lubricants such as turbine and hydraulic oils, is measured in decades, the hydrolytic stability of additives and/or base oils is of considerably importance. Such information can be readily obtained with the RBOT equipment.

STABILITY OF MOTOR OILS

Early during the development of the RBOT, some promising but unpublished work was done on aircraft lubricants. More recently motor oil additives contemplated by a chemical manufacturer were tested in the RBOT with rather startling results. Some of these additives which gave superior results in high temperature oxidation tests in absence of water, failed completely when evaluated in the RBOT. In these instances the failure was not so much due to the hydrolysis of the additives themselves but rather to that of the passivating film formed on the copper surface. Similar information can be obtained by low temperature engine tests such as the FL-2 but at much greater expenditure of time and money.

No published information is available on this subject but it is known that three of the major oil companies in the U. S. who have RBOT equipment are using it in their lube oil research work, as well as for testing turbine oils.

For evaluating lubricants or for testing of bearing metals it has been suggested and appears perfectly feasible to use in the RBOT metallic lead and other catalytically active or corrodible metals or alloys and to determine their weight loss in the test.

One novel and interesting application of the RBOT was referred to in a recent ASLE paper by Kottcamp et al (16) who used the test for evaluating the changes in oxidation stability of turbine oils exposed to high energy ionizing radiation.

SUMMARY

The RBOT is extensively used by oil refiners, additive and equipment manufacturers and turbine operators as a rapid and reliable routine and research test for rust and oxidation inhibited industrial lubricants in the presence of water and also shows great promise for application as a screening test for motor oils and oil additives.

ACKNOWLEDGEMENTS

Many individuals and organizations have contributed to the development of the RBOT and their contributions are gratefully acknowledged. Special mention should be made here of W. Pohl of the Institute of Petroleum of London, England and F. D. Tuemmler of Shell Development Co. Emeryville, California who supplied information on the use of the test in England and of R. G. Call of the American Electric Power Service Corporation Laboratories at Huntington W. Va. who has probably done more work with this test than any other single individual and who is its ardent advocate.

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DISCUSSIONS

by R. B. McBride,
General Electric Company, Schenectady

The comments that follow are based upon experience gained with a Rotary Bomb test unit which was obtained by our laboratory in 1952. Since this time the unit has been employed for tests of new and used turbine oils of Company interest together with tests carried out in conjunction with programs organized within Committee C, Section III on Oxidation of Turbine Oils, ASTM D–2.

Many of the objections to this test which we might raise on the basis of experience with our unit have been nullified by the refinements in equipment and method outlined in von Fuchs' paper. For example, the aluminum block heater which was incorporated into the design of earlier models of the rotary bomb testers (including ours) did not provide precise temperature control—a factor of prime importance in an accelerated test of this type. In addition to this mode of heating the use of stainless steel as the construction material for our bombs produced an objectionable time lag for attainment of test temperature and maximum pressure due to poor heat transfer. This proved especially undesirable for tests involving uninhibited oils. The replacement of the aluminum block heater by a precisely controlled oil bath and the adoption of plated steel bombs are modifications of the equipment which we heartily endorse. We encountered frequent bomb leaks when lead gaskets supplied with the equipment were used but this situation was improved by changing to a silicone gasket material.

With the original procedure for preparing catalyst coils and cleaning bomb after test, considerably more than one day was required to carry out a test run. The changes with respect to catalyst preparation and cleaning procedures proposed by von Fuchs should help to reduce the time requirements for these operations considerably.

Automatic pressure recording devices for monitoring the bombs during test runs would be most welcome additions to the test equipment. Members of our group who stayed with our unit until midnight on several occasions waiting for stubborn oils undergoing tests to reach the breakpoint, would endorse this view heartily.

Von Fuchs points out that the rotary bomb test is currently being employed by several oil companies' laboratories for studies involving stability of oils and additive materials. I might mention here that our laboratory has employed the test in modified form for checking the hydrolytic stability of synthetic fluids being considered for use as fire resistant turbine lubricants.

The data in this paper concerning tests for turbine oils carried out by seveal laboratories would indicate that the modifications in equipment and method proposed by the author have improved correlation of test results between laboratories considerably. In early programs in which our laboratory participated (under the auspices of the ASTM), results of rotary bomb tests between laboratories varied more widely. However, in an accelerated test of this type, precise control of temperature is perhaps the most important factor, and much of the variation in results reported for earlier tests could be attributed to this factor.

It will be noted in data presented by the author for tests of new and used oils at 150 C and 140 C that a doubling of the test lives of the oils occurred when the test temperature was dropped to 140 C. This rather vividly illustrates the need for precise temperature control in the conduct of the test.

A major drawback to the proposed adoption of the rotary bomb test as a short term test for turbine service oils has been the cost of the equipment. This, I believe, is a valid complaint on the part of the small turbine operators who are interested in a short term test for service oils. However, for large operators of turbine equipment and particularly for oil companies conducting routine checks of customer's oils, a further study of the merits of this test for evaluating service oils appears to be warranted.

by D. A. Hall,
Eastman Kodak Co., Rochester

This is a vey well written paper and a very interesting test. Industry has great need of a test like this if it can be correlated with service performance.

As the author points out, there are certain inhibitors which cause sludging or allow sludging, as the case may be, to take place without using much oxygen and without forming acids. Oils containing these inhibitors may show up well in the Rotary Bomb Oxidation Test but may have poor service records.

It would be interesting to know the nature of this sludge and to be able to detect its formation in the bomb without stopping the test and opening the bomb. If this is not feasible,

possibly a series of tests would have to be run for increasing increments of time until the sludging point is found.

The correlation between any accelerated performance test and field service is very important and must not be neglected.

by H. W. McCulloch, Jr.,
Shell Oil Company, Chicago

In this era of "the test's the thing" the need for precise short-term evaluation procedures to assist the refiner, the oil chemist, the researcher, and the lubricant consumer in predicting the performance of a given lubricant for a given application is apparent. However, no single test is likely to provide each of these groups with the exact answer and in the end the ultimate performance in the equipment rather than in the laboratory bench test governs the acceptability of the product. This fact alone should be the basis for choosing a lubricant.

Unfortunately, proof-testing is often too expensive, too time consuming, and too risky to undertake even on the bases of our best educated guess. To overcome this reluctance to take the rick and yet maintain progress in this very competitive industry, lubricant engineers and chemists must turn to the use of the bench tests. One such test meriting consideration is the Rotary Bomb Oxidation Test as just proposed by von Fuchs. Even then it is apparent that the refiner, the researcher and the consumer must each apply different yardsticks to his interpretation of the results. It is this emphasis on the flexibility and potentialities of the tester rather than on the attainment of a high numerical result for which this presentation is commended.

As will be noted when referring to the bibliography appended to the von Fuchs paper, my company has successfully applied one version of the Rotary Bomb Oxidation Test to refinery control testing for many years. I can assure you that the long interval between its initial use and publication was not motivated by selfish gain, but by a reluctance to foist on the industry another test subject to many abuses, mis-uses, and misinterpretations suffered by other of the so-called performance tests. The test has now come of age and, I am hopeful, has our ability to apply it, as well as other tests both singly and in combination with this useful tool.

I would be remiss to overlook von Fuchs' allegation that all circulating oil system complaints involving sludging were due to the use of amine-type inhibitors. This, I feel sure, is due to his personal adversity to their use, or perhaps their mis-use, as it is quite likely that the oil chemist will continue to use them successfully in many formulations in spite of their apparent shortcomings born of some bench tests.

Von Fuchs should be congratulated on his persistence in bringing the Rotary Bomb Oxidation Test to the fore. This activity has already resulted in decreased equipment cost and improved reliability for the test, as well as an aroused interest. Likewise, he should be encouraged to maintain his outlook as most assuredly the Rotary Bomb Oxidation Test will appear on the future list of standard methods for specific product applications.

by R. G. Call,
American Electric Power Service Corporation

Von Fuchs' paper is most timely in view of the current desire for a less time consuming oxidation test.

The author discusses the advantages of oil heating bath over the aluminum block method, with which we agree; but we fail to see how external plating of the carbon steel bomb can improve heat transfer. It is surprising that the author has overlooked the subject of gasket material, which is one of the weak points in this test.

We have used the Rotary Bomb Test for the past five years and the only trouble encountered during this time has been due to faulty gasket materials.

Two types of bombs are used; one requiring a flat type gasket and the other an "O" ring gasket. Lead, PTEF and silicone gaskets have proved unsatisfactory and at present we are cutting he flat gaskets from ⅛ in. duPont "Fairprene" (neoprene) sheeting. The "O" ring neoprene gaskets are available in the open market.

We find the bomb using the "O" ring to be more desirable as ten to 15 runs are obtained before a change of gaskets is needed. The flat gaskets require changing after six runs.

Our use of the Rotary Bomb Test has been confined to the testing of both new and used turbine and transformer oils. Turbine oils are run at 150 C using both copper and iron catalysts, which are discarded after each test. Transformer oils are run at 140 C to avoid oxidation in the vapor phase and the procedure used is similar to the one described by the author for turbine oil. Turbine oils containing synergistic type additives are run at 140 C; as some of these materials lose their properties at 150 C.

Oils from all turbine throughout the American Electric Power Company System are evaluated twice a year and any pronounced deviation in bomb life from the bogey requires investigation as to the cause.

A Staeger Oxidation Test is also made on each oil and the results correlate very well with the bomb results.

The bomb test is included in our specifications for transformer oil, and an acceptable oil with respect to oxidation must have a bomb life of 80 minutes or better.

In no instance have we found an oil passing the bomb test to fail the Doble Oxidation Test. Apart from its use in routine investigations, the bomb test by varying procedures becomes an excellent research tool. For example, new insulating oils have been tested at every five psi drop in pressure up to 25 psi and the data indicates that more information is available at the end of the first five psi drop in pressure than at the end of the test.

Possibly a much better evaluation could be obtained by dropping the temperature to 130 C and concluding the test at a ten psi drop in pressure.

In work of this type, we doubt that the recording gages used by the author are of sufficient accuracy. We use 4 in. test gages calibrated in one psi divisions. The use of the Rotary Bomb Test has been a labor and time-saving proposition with us, for without it our present program of testing could never have been carried out.

by W. Pohl,
Institute of Petroleum

The Rotary Bomb Oxidation Test is in use in a number of British Laboratories for the development and control of inhibited turbine oils, the evaluation of inhibitors and the assessment of the response of base oils to them. Its use has not spread to any great extent to other applications.

The experience of users of the test is in the main in line with that of the Institute of Petroleum (IP) in their investigation of the test during 1952-1955. A review of their work is therefore appropriate as comment on the present paper more especially since only the early part of their work is covered by the 1953 report referred to in Ref. 8 and a subsequent 1955 report appears not to have been available to the author of the paper.

The investigation was undertaken by the Oxidation Panel of Sub-Committee No. 6 (Lubricants) on the request of the British Admiralty for the development of a short term oxidation control test for checking supplies of inhibited turbine oils that had already been approved against either IP.114/47P or ASTM D.943/47T. The test was required in view of a desire to incorporate such a test in a joint specification then being drafted by the British Admiralty and the U. S. Navy. Correlation with the existing IP and ASTM tests was not required, the test being for control and not qualification purposes.

The Panel rapidly came to the conclusion that the RBOT

was probably the best qualified for investigation and their final conclusions were that a modified accelerated form of the test akin to but not identical with that now described as "The New RBOT," gave good repeatability and reproducibility, could be completed within a total of six hours and would probably fulfill the specified requirements.

Although these conclusions were never implemented by the joint Navies and the work of the IP was to that extent abortive, the investigation clearly showed the possibilities of the test as a short term control test and also evaluated the respective merits of various forms of the test. Four variations were investigated by three laboratories using four oils supplied by the British Admiralty as OM approved oils with no details of their provenance or composition. These four variations were as follows:

1. RBOT—Original Version, ASTM Bulletin No. 186 Dec. 1952, Solid Copper/Iron Catalyst

The results given in Table I are those given in the IP February 1953 Report referred to under Ref. 8 of the present paper and were obtained under the then standard conditions of the test with solid copper and iron wire catalyst viz. 90 psi initial oxygen pressure, 150 C temperature, 25 psi drop from maximum as end point.

TABLE I. Solid Catalyst Fe/Cu

	RBOT LIFE (MINUTES)		
	LABORATORY		
OIL	A	B	C
1	195	195	180
	195	195	165
	185		165
	180		
2	75	75	75
	80	65	90
	80	65	80
	75		
3	300	340	315
	310	350	345
	380		345
	290		
	330		
4	165	160	195
	155	160	180
	165		165
	155		

2. RBOT.—Soluble Catalysts Copper/Iron Naphthenates

Soluble catalysts were introduced to obviate the difficulties experienced in cleaning the solid ones. Copper and iron naphthenates were used in concentrations to give 100 ppm of copper and of iron in solution. Pieces of Pyrex glass tubing were introduced into the oil in the glass liner in order to provide agitation of the oil and a greater oil/oxygen interface. In all other respects the conditions were as prescribed in the original 1952 test. The results are given in Table II.

These results are of the same order and as precise as those with the solid catalysts but the duration of the test was markedly reduced to well within one working day. The form of the pressure-time curve was however abnormal and such as to make it difficult to detect small leaks or to define the maximum pressure and hence the end point. Tests under the original conditions with solid catalysts gave curves of the form shown in Fig. A1, Type A whereas the tests with soluble catalysts gave curves of Type B which is precisely that given with a leaky bomb under solid catalyst conditions. Moreover doubts were expressed about the reproducibility of a standard quality catalyst.

For these reasons and because of the good results obtained by the alternate use of all copper wire, the use of soluble catalysts was abandoned.

TABLE II. Soluble Catalysts Cu/Fe

	RBOT LIFE IN MINUTES		
	LABORATORY		
OIL	A	B	C
1	165	155	
	170	155	
		140	
		150	
2	75	75	
	70	75	
		65	
		70	
3	380	390	
	295	420	
		450	
		480	
4	190	150	
	185	155	
		165	
		155	

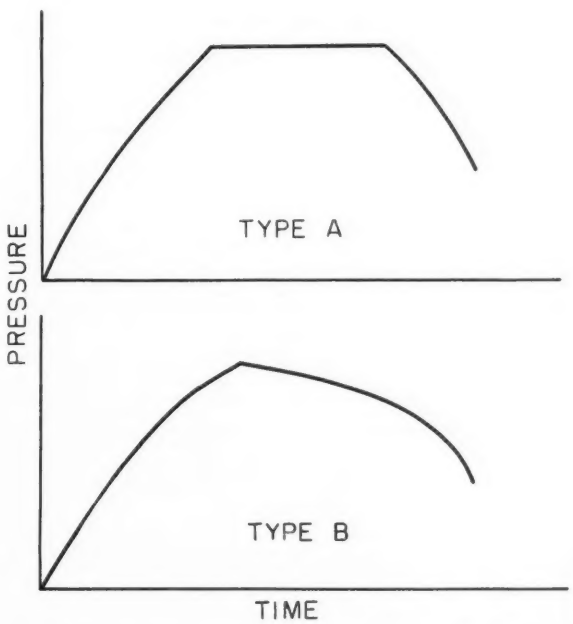

Fig. A1. Pressure-time curves—type A—solid catalysts—type B—soluble catalpts.

3. RBOT—Solid Catalyst/Copper Only

During the course of the work on soluble catalysts and as a result of the criticisms of the original solid catalysts a suggestion was received from von Fuchs to replace the iron wire by copper wire and to prepare the copper by heating the coils

rapidly to dull red heat and immediately plunging into methanol—a method already used successfully in the Swedish A.S.E.A. oxidation test for transformer oils.

Table # 3 gives the results of tests under these conditions (four copper coils in place of two copper and two iron) together with further modifications also suggested by von Fuchs, viz. reduction in quantity of oil from 60 to 50 ml, reduction of water from 20 to five ml and the use of 15 ml of water in the bomb to improve heat transfer between the bomb wall and the glass liner.

TABLE III. Solid Catalyst Cu

	RBOT LIFE IN MINUTES		
	LABORATORY		
OIL	A	B	C
1	135	130	150
	150	135	155
	155	130	
	145	130	
2	50	45	45
	45	50	55
		55	
		40	
		45	
3	240	260	
	250	270	
4	130	130	135
	125	135	135
	135	120	
	125	130	
		130	

The precision of these results was as good as that of the previous ones and also the duration of the test was markedly reduced, no doubt due to the better heat transfer.

The RBOT under these conditions was accordingly recommended as suitable for the Navy requirements.

4. RBOT—Mixed Catalysts Solid Copper/Soluble Iron

A further modification of the test was investigated using sufficient soluble iron naphthenate to give 100 ppm soluble iron in addition to the four coils of solid copper prepared as before by heating to a dull red and plunging into methanol. The results are given in Table IV.

TABLE IV. Mixed Catalyst—Solid Cu—Soluble Fe

	RBOT LIFE IN MINUTES		
	LABORATORY		
OIL	A	B	C
1	155	140	150
	145	140	
2	80	85	90
	85	85	
3	240	270	270
	305	265	
4	145	135	
	145	145	

The precision of these results was again satisfactory and the order of rating remained the same. Moreover the pressure/time curve reverted to the normal Type A with a characteristic plateau at the maximum value. However, no advantage was offered by the introduction of the solube iron catalyst and no further study was made of this variation.

Summarizing the IP work, they showed:

1. That a method closely akin to the presently proposed "New RBOT" (all copper coils, water in bomb) could be a satisfactory short term oxidation control test for inhibited turbine oils.
2. That these conditions not only eliminated the laborious cleaning of the iron wire which has always presented more trouble than that of the copper but also simplified the cleaning of the copper.
3. That these conditions reduced the heating up period, i.e. the time taken for the bomb pressure to reach its maximum from about 60 mins for the original 1952 method to about 15-20 mins.
4. That these modifications reduced the RBOT life of oils without introducing any anomalies in the order of rating and without sacrifice in precision.
5. That the use of soluble catalysts was undesirable because of the less precise form of the pressure-time curve and the doubts about reproducibility of quality of catalyst.
6. That the use of a mixed solid copper/soluble iron catalyst gave satisfactory results but offered no advantage.

In addition to the above comments derived from the work of the Institute of Petroleum I would like to offer a few general comments on the paper as such.

The author has modestly attributed the method to others (Ref. 7) whereas the IP faithfully followed his own prescription as given under Ref. 6.

I know of no experience in the UK with the "New RBOT" described in the paper but on the basis on the IP work under somewhat similar conditions the claims for an "improved and simplified" version are no doubt justifiable. I am doubtful, however, whether the reduction in the heating up period is much due to the change from stainless to plated plain steel bombs and think it due to the use of water between the bomb and the liner. This is borne out by the IP work in which with the same bomb the introduction of water reduced the heating up time from about 60 to about 15 min. which is of the same order as now claimed. The disadvantages of aluminum block as opposed to oil bath heating were also experienced in the IP work in which one laboratory used an aluminum block.

Although the new RBOT has eliminated the tedious procedure for cleaning the catalyst, the method now proposed is less attractive than the earlier one used by the IP, viz., unattached coils heated to redness and plunged into methanol. A build-in copper catalyst cleaned and reused in situ seems less likely to provide a reproducible surface however elaborate and meticulous is the cleaning process. The author indeed recognizes the danger. Moreover the use of NaCN is not likely to be welcomed in many control laboratories. The use of fresh catalyst on each occasion has much in its favor and the saving on material achieved by the new proposal is surely hardly worth while.

The question of correlation between the RBOT and the TOST is an interesting one. Although the IP made no investigation of this as being outside their terms of reference, they expressed the view that correlation between the RBOT and other well known tests was not to be expected and was indeed contrary to the experience of some of the participants except on a limited scale when dealing with a particular oil-inhibitor blend. The author's statement "While the close correlation between the RBOT induction periods and TOST oil lives was pointed out earlier (6). . . ." seems to imply a correlation irrespectively of the type of oil. It is generally acknowledged

that this is not so as the author himself has amply shown in Table IV of the article referred to in (6) with the conclusion "Thus the prediction of the behaviour of an oil in the D.943 test from the bomb test can be very misleading with oils of unknown composition." This has been borne out by general experience in UK laboratories.

I know of no substantial UK evidence of correlation between the RBOT and service performance—indeed the long life of inhibited turbine oils virtually precludes it. Nevertheless the experiences quoted with sludge due to amine inhibitors is in line with results in the TOST and other oxidation tests and it is of interest to learn that the RBOT can also be used to demonstrate or detect its formation.

AUTHOR'S CLOSING REMARKS

The correlation between RBOT and TOST induction periods is dependent on the inhibitor used as shown in Reference 6. In the interest of clarity, the inhibitor dependence of this correlation should have been re-stated in the paper. Far more significant, however, is the correlation in sludge formation shown by the two tests.

It is agreed that not all sludging difficulties experienced in oil circulating systems are caused by amine type antioxidants. As pointed out in Reference 5, sludging and rust formation may be due to incompatibility between certain oil additives or to impure, corrosive or hydrolytically unstable oil constituents, poorly refined base oils, etc., even in the absence of amines.

Among catalytically active metals, copper is the easiest to prepare and to reclaim. It should be used as catalyst in the rapid routine testing of known oils and particularly of oils from service. In research work or when evaluating new oils of unknown composition, it is often preferable to use two or more metals, the choice depending on the kind of catalytic or corrodible metals which the oil will encounter in service. Thus for new turbine and hydraulic oils a combination of copper and iron catalysts is best. Wide flexibility in possible test conditions is one of the advantages of the rotary bomb oxidation test.

During the early development stages of RBOT, lack of satisfactory gasket materials presented some problems. Gaskets made from silicone rubber seal easily and exceedingly well. However, due to insufficient mechanical strength, their re-use is limited. Newly developed and improved high temperature synthetic elastomers having superiod tensile strength and good resistance to compression set hold promise to increase the durability of RBOT gaskets.

In closing, it is with considerable pleasure that I acknowledge the many valuable contributions the discussers made to the advancement of the RBOT. Thanks are also due to the ASLE National Program Committee for suggesting the presentation of prepared discussion by industry representatives interested in the test.

A SURVEY OF WAY LUBRICATION PROBLEMS PECULIAR TO SERVO-CONTROLLED MACHINE TOOLS

(Con't. from p. 21)

Now that it has been shown possible to straighten and flatten the curve, it remains only to rotate the whole curve counterclockwise so as to simulate the pure viscous drag situation. It is supposed that the introduction of high viscosity oils would merely increase the film thickness without changing the slope of the line appreciably but this has not been confirmed experimentally.

CONCLUSIONS

Several commercially available oils are satisfactory for the lubrication of servo-controlled machine slides as they are now used. More advanced designs may require more custom compounded oils. The oil should be considered part of the servo system.

Through design, the natural handicap imposed by hydrodynamic effect can be minimized. The effect of stiction can be materially reduced both by oil selection and design. Although one might not normally believe it to be the case, friction can be reduced to the point where it is too low.

ACKNOWLEDGMENTS

The author wishes to thank James Mason and Richard Syverson of the experimental staff for permission to use material from their original test report on this project.

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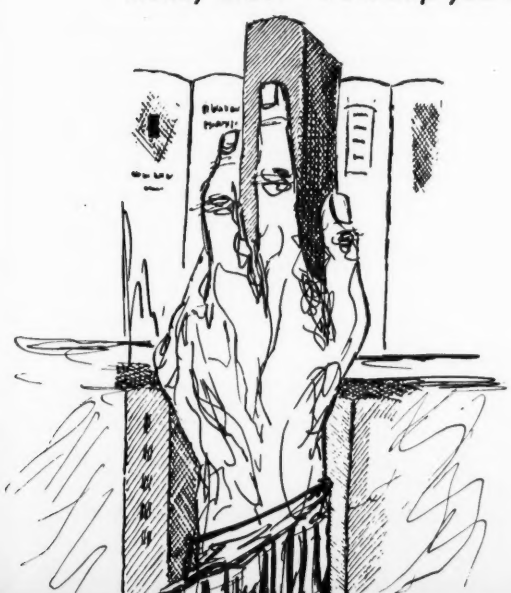

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Lubrication Abstracts

Edited by W. E. Campbell

Selected literature compiled by members of the Technical Committees and Industry Councils of the Society.

"New Problems—New Oils." John V. Kalb, Diesel Power, v. 36, n. 8, August, 1958, pp 24-6.

Problems associated with use of residual fuel in diesel engines are discussed. Lube oils must neutralize the effect of high sulfur content, have E.P. properties, spread well over the cylinder, produce no injurious combustion products. A new, wholly soluble additive in an experimental lube oil compared with MIL-L-2104A oils in the same power plant diesel shows reduction of ring and liner wear. (Abstracted by G. C. Lawrason.)

"A Study of Piston-Ring Lubrication." Samuel Eilon and O. A. Saunders, Proceedings of the Institution of Mechanical Engineers, v. 171, no. II, 1957, pp. 427-43.

A laboratory rig with reciprocating liner and stationary piston, equipped with an electronic means of measuring instantaneous friction force on the piston, is used to study the effects of oil viscosity and ring speed and pressure. Oil film thicknesses, as calculated from the data generated, are compared with similar figures derived from a theoretical formula proposed by the authors. Ring design suggestions are presented. (Abstracted by G. C. Lawrason.)

"Viscosity is Still the Key to Good Lubrication of IC Engines." William Kaufmann, Power, v. 102, no. 7, July 1958, pp. 110-12, 158.

Viscosity is the most important lube oil characteristic in operation of diesel engines. The most critical points are piston-cylinder area and main and connecting rod bearings. Good fuel, proper maintenance, and proper operating conditions are essential. Multiviscosity oils have an important place in cold starting. (Abstracted by G. C. Lawrason.)

"An Investigation into the Mechanism of Oil Loss Past Pistons." P. de K. Dykes, Proceedings of the Institution of Mechanical Engineers, v. 171, no. II, 1957, pp. 413-26.

A carefully fabricated bench test rig is used to evaluate various parameters of piston and piston-ring design for their effect on crankcase oil consumption. Combustion chamber pressure and cycles per unit time are varied. Results indicate that a large quantity of oil is carried toward the combustion chamber past the rings during part of the cycle, but returns to the sump at another point in the cycle if the ring-piston combination is efficient. The relation of the piston lands, and particularly the top land, to the cylinder wall is an important oil consumption factor. Re-entry of oil from the chamber to the sump past the piston is facilitated by a tapered top ring. (Abstract by G. C. Lawrason.)

"A Dynamic Theory of Piston-Ring Lubrication." S. Furuhama. Japan Soc. Mech. Engrs. Trans., v. 24, no. 148, Dec. 1958, pp. 1032-9. (In Japanese).

Near the top dead center of the expansion stroke of an engine, the piston-ring speed is zero and its load and temperature reach a maximum. Based on the steady-flow hydrodynamics, the oil film between the ring and the cylinder would have to be broken down. In practice, however, fluid-film lubrication is achieved in the high speed region. The piston ring speed and load vary so extremely that oil film thickness changes rapidly, and this rate of change in film thickness generates load carrying capacity by the squeeze action. This paper introduces the equations of the squeeze-film theory, and some calculations are carried out for a ring, the surface profile of which consists of the quadratic and the parallel line. (Edward H. Loeser.)

Lubrication of High Speed Tapered Roller Bearing by Atomized Oil." T. Sasaki, N. Okino and T. Fujita. Japan Soc. Mech. Engrs.—Trans. v. 24, no. 146, Oct. 1958, pp. 697-702. (In Japanese).

The operating characteristics and the mechanism of lubrication of high speed tapered roller bearings are investigated when lubricated by atomized oil. The effects of oil consumption, air consumption, oil viscosity, load and rotating speed are studied. Lubrication by atomized oil lessens the friction markedly and controls the bearing temperature in a suitable manner. It is concluded that the atomized oil functions mainly in a hydrodynamic fashion. The friction moment and temperature rise of a tapered roller bearing are deduced from theoretical hydrodynamic considerations and are found to agree with the experimental results. (Edward H. Loeser.)

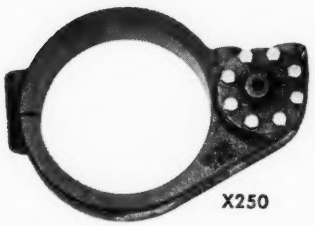
"Harmful Effects of Electrostatic Charges on Machinery and Lubricating Oils," T. Salomon, J. Inst. Petrol. v. 45, 1959, pp. 47-68. Abstr. ibid, p. 139A.

A number of incidents of abnormal behavior of turbine oils due to electrostatic charges created within the turbine are surveyed. It is concluded that such charges, which can be produced during the lubrication of machinery, play a significant part in the lubrication process, particularly in the formation of oil films and in pitting wear. The concept of a shock wave as being the primary cause of wear is presented. It is pointed out that the usual interpretation of the ohmic resistance of an oil film as a means of measuring film thickness does not take sufficiently into account the special dielectric properties of thin oil films. Such films can, under certain conditions, behave as perfect conductors. (Edward H. Loeser.)

"Effect of Surface Conditions During the Wear of Tungsten Carbide." J. Golden and G. W. Rowe, Radioisotopes Sci. Research, Proc. Intern. Conf. Paris 1957, n. 1, pp 343-361 (Pub. 1958).

After neutron activation of the surface to produce W^{187}, the active fragments are detached by a sliding process and can be quantitatively assayed by a scintillation counter or by autoradiography. Results show that the wear is very dependent on the mech. and chem. state of the surface. Scratches left by 20-μ abrasive papers on Cu disks can cause sudden sharp increases in wear. Residues left by ammoniacal etching increase wear, while those left by aq. HCl decrease the wear, even after careful washing. Standard prepn: techniques, such as benzene or alc. degreasing, are found to leave contaminant films which also reduce wear. When polished, WC wears more smoothly, but more heavily than when etched. Oxide films increase the wear on Cu. There is a direct relation between film thickness and wear rate. The wear is nearly proportional to the friction force. (Chemical Abstracts.)

(Con't. on p. 40)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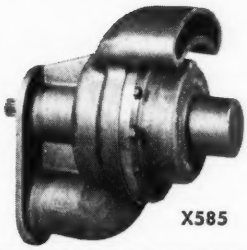
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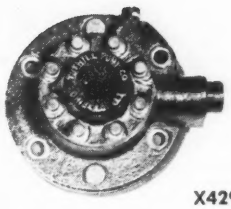
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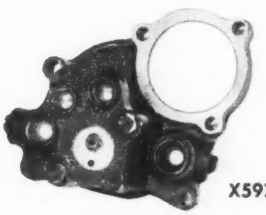
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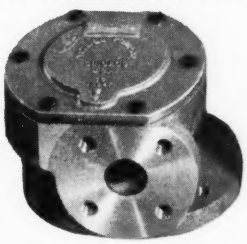
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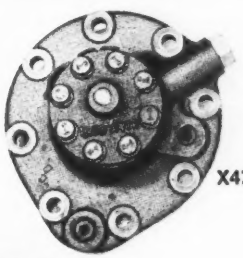
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Tuthill pumps may be supplied with a wide variety of shaft seals for use with various fluids. They can incorporate strainers, as model X585 above. They may be provided with, or without, built-in relief valves. They can incorporate a wide variety of special shaft modifications or gearing to accommodate various driving units.

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Patent Abstracts

Compiled by Ann Burchick
Aluminum Co. of America

Process for Lithium Base Grease, Patent #2,898,298 (H. C. Zweifel, H. J. Voss and H. D. Gower, assignors of one-half to Sinclair Refining Co. and one-half to Richfield Oil Corp.) In the manufacture of a lithium grease of a mineral oil base and about five to 25 weight per cent on the grease of a lithium soap of which at least 80 per cent by weight is a lithium soap of hydrogenated castor oil, which grease is characterized by uniform homogeneity and dispersion of gel structure and by the presence of the soap in the form of fibers of about one micron length, which comprises saponifying the fatty component with an aqueous lithium base in the presence of at least a portion of the total oil base to be used in the grease composition, dehydrating the mixture at a maximum temperature of about 330F, adding any additional amount of oil base needed to formulate the grease, and colloidally milling the unhomogenized grease to provide gel strength in terms of ASTM penetration for the homogenized grease equivalent to about 25 to 125 penetration points increase in hardness relative to that of the grease in the unhomogenized state.

Rust Preventive Compositions, Patent #2,898,301 (R. L. Mayhew, J. P. Copes and E. P. Williams, assignors to General Aniline & Film Corp.) An antirust composition comprising a fluid petroleum hydrocarbon containing in a rust inhibiting amount of at least one N-substituted-γ-hydrocarboxylic acid amide.

Lubricants, Patent #2,898,331 (A. Dorinson, assignor to Sinclair Refining Co.) A sulphur-chlorinated oil-soluble ester of chlorendic acid produced by reacting a sulphur chloride and an oil-soluble chlorendic acid ester in a ratio of about .5 to two moles of sulfur chloride to one mole of a chlorendic acid ester wherein said ester group is an unsaturated aliphatic hydrocarbon radical containing from three to 20 carbon atoms.

Calcium Base Grease Containing a Nickel, Lead or Lithium Salt of a Dialkyl Dithiophosphoric Acid Diester, Patent #2,899,388 (J. W. Nelson and M. P. Kleinholz, assignors to Sinclair Refining Co.) A lubricating grease composition consisting essentially of a major portion of a base mineral lubricating oil thickened to grease consistency with anhydrous calcium 12-hydroxy stearate and about 0.1 to 5.0 per cent by weight of an oil-soluble metal salt of a dialkyl dithiophosphoric acid diester, said alkyl groups containing about four to 12 carbon atoms, and the metal of said salt being selected from the group consisting of nickel, lead and lithium.

Non-Staining Aluminum Rolling Lubricant, Patent #2,899,390 (J. J. Plemich, assignor to Standard Oil Co.) A non-staining aluminum rolling lubricant which consists essentially of an undiluted polybutene, prepared by polymerizing butenes from a butane-butylene stream, which polybutene has a Saybolt viscosity at 100F in the range of about 40 to 80 seconds, which boils in the range of about 460 to 645F, which has an average molecular weight in the range of about 200 to 270, and which polybutene contains about one per cent of butyl stearate.

Corrosion Preventive Compositions, Patent #2,900,262 (H. A. Green, assignor to Quaker Chemical Products Corp.) A liquid corrosion preventive composition for metal surfaces consisting essentially of a petroleum hydrocarbon and the reaction product of from one to 15 parts by weight of a petroleum hydrocarbon oxidate with one part by weight of the product obtained from condensation under dehydrating conditions of about one to two mols of a mono carboxylic acid containing from eight to 22 carbon atoms and about one mol of a polyalkylene polyamine selected from the group consisting of polyethylene polyamines and polypropylene polyamines containing from two to four alkylene groups and from three to five amino groups and hydroxyalkyl alkylene diamines containing from two to three carbon atoms in the alkyl group and from two to three carbon atoms in the alkylene group, said petroleum oxidate consisting essentially of a mixture of high molecular weight aliphatic acids, hydroxy-carboxylic acids, alcohols, keto-alcohols, keto-acids, esters, lactones, ketones and partially oxidized hydrocarbons having five to 35 carbon atoms, said oxidate having a mean molecular weight in the range of 200 to 600, acid number in the range of ten to 200, saponification number in the range of 40 to 300 and an unsaponifiable content in the range of ten to 70 per cent by weight.

Lubricating Oil Containing a Wax Pour Point and Cloud Point Suppresser, Patent #2,900,322 (H. J. Zoeller, assignor to Esso Research & Engineering Co.) A hydrocarbon oil to which has been added as a haze and cloud point suppressor from about 0.001 per cent to about 0.02 per cent by weight of a petroleum wax composition melting in the range between about 100F and about 118F, said composition containing about 45 to 55 mol. per cent of normal paraffin waxes, about 15 to 25 mol per cent of isoparaffin waxes, and about 15 to 25 mol per cent of naphthenic waxes.

Mineral White Oil Treatment, Patent #2,900,333 (J. F. Collins and R. V. Sheehan, assignors to Esso Research & Engineering Co.) In a process for washing a white oil formed by sulfuric acid treatment following neutralization of the treated oil to remove color-forming organic impurities from said oil, the improvement which comprises washing said oil with about equal parts of a washing solvent formed by combining an aqueous isopropanol containing 40 to 60 vol per cent isopropanol with a low molecular weight aliphatic Oxo organic solvent which boils in the range of 56.5 to 97C and dissolves less than three vol per cent C_{20+} paraffinic oil, so that said washing solvent contains five to 30 vol per cent of said Oxo organic solvent.

Glass Fiber-Thickened Grease Compositions, Patent #2,900,338 (W. Postelnek, assignor to the United States of America as represented by the Secretary of the Air Force) A lubricating composition consisting essentially of a lubricating oil thickened to a grease consistency by from two to 15 per cent by weight of glass fibers, said fibers having a diameter less than three microns.

Process for Preparing Lubricant Compositions and Concentrates Therefor, Patent #2,900,339 (W. Lowe, assignor to California Research Corp.) A process for producing

stable dispersions of more than 0.15 per cent by weight of terephthalic acid in a mineral lubricating oil which comprises reacting terephthalic acid with a tertiary amine selected from the group consisting of tertiary hydrocarbon amines and tertiary hydroxy alkyl amines containing a total of from five to 15 carbon atoms in proportions of at least 20 moles of tertiary amine per mole of terephthalic acid, combining the reaction mixture thus obtained with the mineral lubricating oil containing calcium petroleum sulfonate, which oil analyzes at least about 0.2 per cent by weight calcium, heating the combined oil and reaction mixture to liberate the tertiary amine and separating the tertiary amine and the resulting dispersion of terephthalic acid in mineral lubricating oil.

Anhydrous Calcium Base Greases Containing Free Fatty Acid, Patent #2,900,340 (T. W. Martinek and E. T. Fronczak, assignors to The Pure Oil Co.) An anhydrous calcium soap grease comprising viscous mineral oil treated with sufficient sodium hydroxide to neutralize naturally occurring acids and a gelation agent, substantially all of said gelation agent in the grease, except the soap resulting from the neutralization of the naturally occurring acids present in the mineral oil, consisting of calcium soaps of mixed acids from group (1) saturated monohydroxy fatty acids containing from 18 to 24 carbon atoms per molecule, and group (2) non-hydroxy fatty acids having not more than one unsaturated linkage in the molecule and containing from 18 to 24 carbon atoms per molecule, the group (1) acids constituting approximately 25-75 per cent by weight of the mixed acids of said calcium soaps and the group (2) acids constituting approximately 75-25 per cent by weight of the mixed acids of said calcium soaps and the gelation agent being present in an amount which will produce a gelled grease structure, and free fatty acids selected from the group consisting of above-defined group (1) acids and above-defined group (2) acids and mixtures thereof in a weight ratio to said gelation agent of 0.3-1.85:20.

Extreme Pressure Lubricant Additive, Patent #2,900,341 (J. Lyons, O. C. Elmer, and R. E. Berry, deceased, by M. E. Berry, administratrix, assignors to Texaco Inc.) An extreme pressure lubricating oil comprising a mineral lubricating oil and a minor amount of the halogen-containing product of the reaction of about one to three moles of a polyhalogenated aliphatic carboxylic acid ester wherein the acid portion has from six to 22 carbon atoms and the alcohol portion has from one to 12 carbon atoms with about 0.5 to five moles of a metal salt of an organic mercaptan, said metal selected from the group consisting of alkali and alkaline-earth metals, sufficient to improve the extreme pressure property of said oil.

Lubricants, Patent #2,900,342 (A. A. Manteuffel, G. R. Cook and W. W. Cortiss, assignors to The Pure Oil Co.) A lubricating oil composition, exhibiting load carrying ability, comprising a mineral lubricating oil and from about 1.0 to about 50.0 weight per cent of an epoxidized alkyl ester of an unsaturated fatty acid.

Mold Release Agent, Patent #2,901,361 (F. W. Meisel, Jr., assignor to Allied Asphalt & Mineral Corp.) A mold release agent for spraying or painting on the surfaces of a mold or the like consisting essentially of a water emulsion including a substantially homogeneous mixture of an estersil and a liquid release material selected from the class consisting of oils, waxes, greases, esters, polyalkylene glycol, and glycerol, and an emulsifying agent consisting essentially of substantially five parts hydrophobic polyoxyethylene lauryl ether and ten parts hydrophilic polyoxyethylene lauryl ether, the proportions by weight of water, estersil, and release material being substantially in the ratio of 48: 2.5:32.5.

Copolymers of Propylene and Piperylene as Grease Thickeners, Patent #2,901,432 (A. J. Morway, C. W. Seelbach and D. L. Cottle, assignors to Esso Research & Engineering Co.) A lubricating grease composition comprising a major proportion of a lubricating oil and a grease thickening amount of a copolymer of propylene and piperylene containing about 1.0 to 50 wt per cent piperylene and 99 to 50.0 wt per cent propylene, said copolymer having a molecular weight within the range of about 1,000 to 5000, 000 and being prepared by copolymerizing at pressures below 1000 pounds per square inch in the presence of a catalyst comprising a mixture of a reducing metallo-organo compound and a reducible metal compound.

Lubricating Oils Thickened to a Grease with Hydrous Metal Salts and Process for Forming Same, Patent #2,863,847 (A. J. Morway, assignor to Esso Research & Engineering Co.) A lubricating grease composition which comprises a lubricating oil base stock thickened to grease consistency with from five to 30 weight percent of a hydrous mixture of a metal salt of a low molecular weight mono-carboxylic acid having from about one to three carbon atoms per molecule and a metal salt of an intermediate molecular weight monocarboxylic acid having from about seven to 10 carbon atoms per molecule, in which the mol ratio of low to intermediate molecular weight carboxylic acids is between 2:1 and 40:1, wherein said hydrous composition contains 0.5 to 15.0 weight per cent water and said metal is selected from the group consisting of alkali metals, alkaline earth metals and heavy metals of groups I, II, IV and VIII of the periodic system.

Foam Inhibition In Hydrocarbon Oils, Patent #2,862,885 (R. S. Nelson and C. W. West, assignors to Union Carbide Corp.) A hydrocarbon oil containing a minor amount sufficient to inhibit foam of a homopolymer of a mono-vinylalkoxysilane having a molecular weight of at least about 325 which had been polymerized through the vinyl group.

Compositions for Use as Hydraulic Fluids, Patent #2,862,886 (P. L. Davies and G. D. Galvin, assignors to Shell Development Co.) A substantially non-flammable composition of matter for use as a hydraulic fluid comprising

	Per cent by weight
A trialkyl phosphate wherein each alkyl radical has from four to nine carbon atoms	30-50
A triarylphosphate containing from 18 to 33 carbon atoms per molecule	5-35
A viscosity index-improving polymerized ester of C_8 to C_{16} aliphatic alcohols and methacrylic acid having an average molecular weight of at least about 25,000	5-10
A chloro(fluoromethyl) benzene having a boiling point above about 75C and a pour point below about —5C	30-60

Flange Lubricants, Patent #2,863,833 (H. H. Jones and F. E. Davidson, Jr.) A lubricant consisting essentially by weight; sulphur from 54 per cent to 70 per cent; hydrated magnesium silicate from 10 per cent to 22 per cent; graphite from 10 per cent to 22 per cent; and chlorinated diphenyl from two per cent to 10 per cent.

High V. I. Detergent Lubricating Oils, Patent #2,863,834 (J. P. Buckmann, assignor to Union Oil Co. of California) A high V.I. detergent lubricating oil composition comprising a major proportion of mineral lubricating oil and a small amount sufficient to impart detergency and high V.I. characteristics to said oil of an oil-soluble metal salt of the product obtained by reacting an olefin-diolefin copolymer having a molecular weight between 5,000 and 200,000 with a dialkyl hydrogen phosphite in which the alkyl groups each contain 1 to 4 carbon atoms at a temperature between 75C and 225C in the presence of an organic peroxide catalyst and hydrolyzing the reaction product, said copolymer being a copolymer of a C_3 to C_4 olefin with a C_4 to C_5 diolefin.

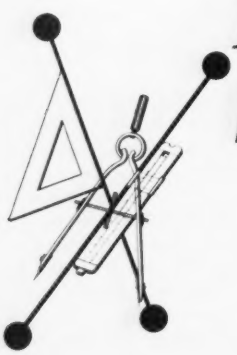
Inorganic Gel-Thickened Lubricant of Good Temperature Susceptibility and Dynamic Water Stability Characteristics, Patent #2,828,-260 (E. C. Milberger, assignor to The Standard Oil Co.) A thickened lubricant of high temperature stability and good dynamic water resistance, consisting essentially of a mineral lubricating oil of lubricating viscosity as the major component, a finely-divided inorganic water-susceptible oil thickener in an amount sufficient to impart a grease consistency to the oil, a water-insoluble oil-miscible polyalkylene glycol diether having a viscosity at 100 F within the range of from 40 to 500 ssu, and a water-insoluble oil-dispersible cationic surface-active imidazoline having an aliphatic group substituted at the two-position and a hydrophilic group substituted at the one-position of the imidazoline, said glycol diether being in an amount within the range from 0.25 to about 2.5 per cent by weight of the thickened lubricant, and said imidazoline being in an amount within the range from four to 14 per cent by weight of the inorganic water-susceptible oil thickener, each being in amounts sufficient in combination to impart high temperature stability and dynamic water resistance to the thickened lubricant.

Inorganic Gel-Thickened Lubricant Having Good Temperature Susceptibility and Dynamic Water Stability Characteristics, Patent #2,828,261 (E. C. Milberger and F. Veatch, assingors to The Standard Oil Co.) A thickened lubricant of high temperature stability and good dynamic water resistance, consisting essentially of a mineral lubricating oil of lubricating viscosity as the major component, a finely-divided inorganic water-susceptible oil thickener in an amount sufficient to impart a grease consistency to the oil, a water-insoluble oil-miscible polyalkylene glycol ether having one terminal hydroxy group and a sufficient proportion of oxyalkylene units of at least three carbon atoms to impart water-insolubility, and a viscosity at 100 F within the range of 285 to 1145 ssu, and a water-insoluble oil-dispersible cationic surface-active imidazoline having an aliphatic group substituted at the two-position and a hydrophilic group substituted at the 1-position of the imidazoline, said glycol ether being in an amount within the range from 0.25 to about 2.5 per cent by weight of the thickened lubricant, and said imidazoline being in an amount within the range from four to 14 per cent by weight of the inorganic water-susceptible oil thickener, each being in amounts sufficient in combination to impart high temperature stability and dynamic water resistance to the thickened lubricant.

Soap-Salt Complex Thickened Grease Compositions, Patent #2,828,262 (A. J. Morway, assignor to Esso Research & Engineering Co.) A lubricating grease composition comprising a mineral lubricating oil thickened to a grease consistency within the range of three to 50 wt per cent of a soap-salt complex consisting of a metal salt of in the range of five to 20 wt per cent of a low molecular weight monacarboxylic acid having in the range of one to three carbon atoms per molecule, a metal salt of in the range of one to five wt per cent of an ethylene diamine tetra aliphatic carboxylic acid, the carboxylic acid groups thereof having in the range of one to four carbon atoms, and a metal soap of in the range of three to 15 wt per cent of a high molecular weight carboxylic acid having in the range of 12 to 30 carbon atoms per molecule, the weight percentages being based on the total grease composition, the metal constituent of said metal salts and soap being an alkaline earth metal and said complex being formed at a complex-forming temperature in the range of 400 to 550 F.

Water-Resistant Sodium Greases Containing Amides, Patent #2,828,263 (H. J. Worth, assignor to Union Oil Co. of California) A water resistant sodium soap grease consisting essentially of mineral lubricating oil and thickening proportions of sodium soap and containing between about 0.5 per cent and about five per cent of an amide product obtained by reacting under dehydrating conditions an amine selected from the class consisting of alkylene diamines having two-eight carbons per molecule and alkyl monoamines having one to ten carbon atoms per molecule with a fatty acid selected from the class consisting of hydroxy and keto fatty acids having 12 to 22 carbon atoms per molecule.

Method of Preventing Staining of Aluminum During Annealing, #2,829,076 (H. M. Rue, assignor to Sun Oil Co.) In the annealing of aluminum having a surface film of hydrocarbon lubricant thereon, the method of preventing staining of the aluminum surface which comprises subjecting the aluminum to an annealing temperature in the presence of a surface film of lubricant comprising hydrocarbon oil having incorporated therein a minor amount of elemental sulfur between 0.05 per cent by weight and the amount required to saturate the oil at atmospheric temperature.



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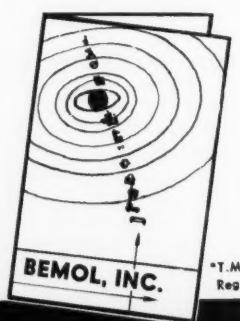

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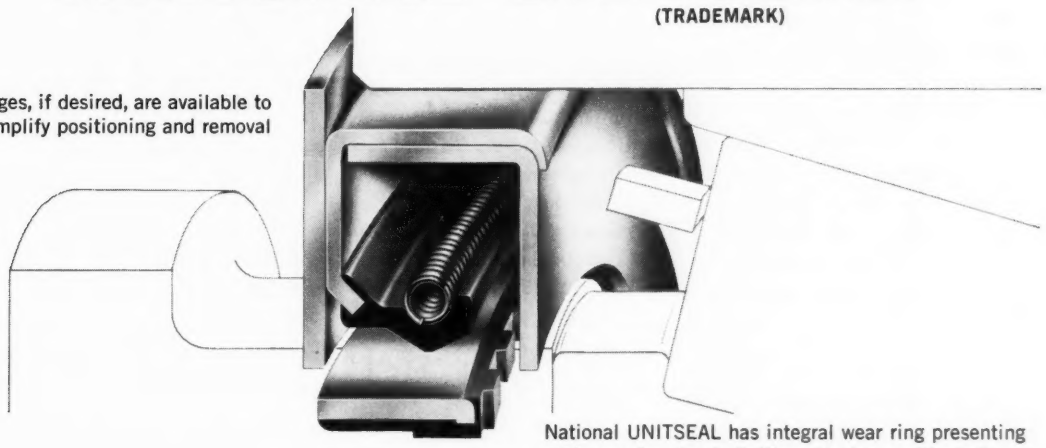

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LUBRICATION ABSTRACTS

(Con't. from p. 34)

"Electrochemical Nature of Corrosion of Metals in Lubrication Oils," I. A. Ptashinskii and R. I. Guseva. *Khim. i Tekhnol., Topliva*, v. 3, no. 5, 1958, pp. 65-8. (In Russian).

NACE Abstract No. 16731. Voltage changes generated between copper and lead electrodes in a bath of lubricating oil indicate that corrosion of metals in oils is an electrochemical process. The two electrode plates separated by a gap of 1 mm are partly immersed in an oil bath in a thermostat at 140 C for 3 hours or more while passing air therethrough at the rate of 0.05 liters per minute. One series of experiments is conducted with ordinary oils and the second with the same oils plus 5% of TsIATIM-339 additive (composition not given). With plain oils, the voltage rises in 3 hours to a maximum and then decreases during the next 11 hours. The first period reflects chiefly progressive oxidation of the oil and the second, after the maximum, the formation and accumulation of the lead salt. The voltage curve for oils with the additive shows a sharp drop within 1 to 1.5 hours, apparently because the additive has an inhibiting effect on oxidation. Thereafter the action of the additive is manifested by gradual rise of voltage over 4 to 5 hours and formation of a colored protective film on the electrode surface. The results are confirmed by polarographic determination of lead in the oil. (Abstracted by E. H. Loeser).

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(Con't. from p. 9)

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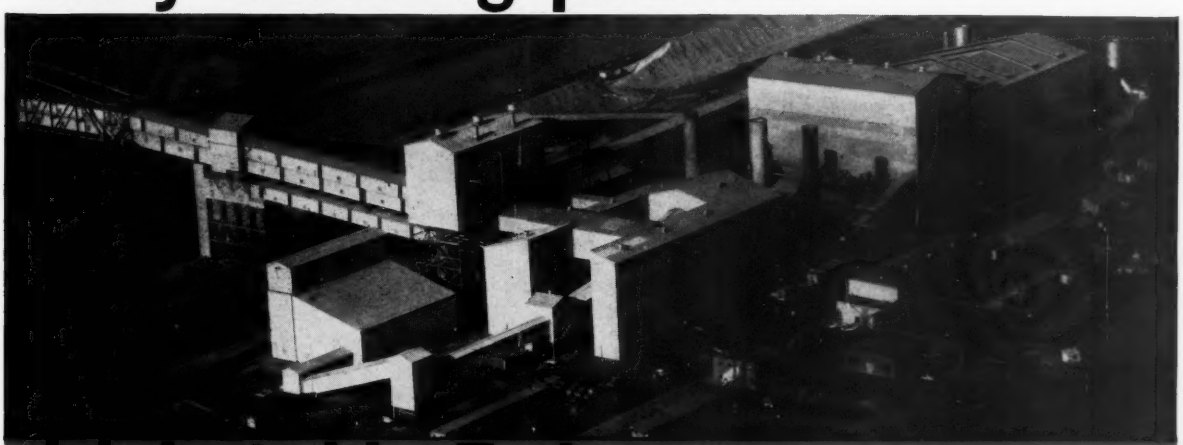

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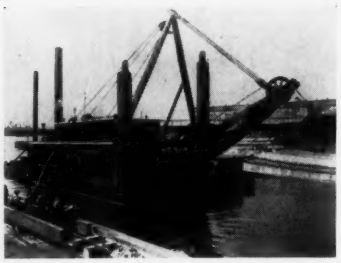

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